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ABSTRACT

This unit studies enquiry as a type of educational goal and examines ways in which the teaching of enquiry is becoming a key emphasis in elementary and secondary schools. The unit's objectives focus on the definition and requirements for enquiry-focused instruction, a rationale for enquiry-focused instruction, the relations between ideas and enquiry, models for enquiry, analyzing curricula in terms of enquiry, analyzing instruction in terms of enquiry, and assisting a school district in introducing enquiry-focused instruction. (Author/IRT)

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TRAINING FOR LEADERSHIP IN LOCAL EDUCATIONAL IMPROVEMENT PROGRAMS

UNIT 5. ENQUIRY AS A THEME OF EDUCATIONAL REFORM, WITH RELATED INNOVATIONS

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PREFACE

This is one of 10 units in a program of Training for Leadership in Local Educational Improvement Programs. Development of the program was begun at the Learning Research and Development Center at the University of Pittsburgh and has been carried forward at Research for Better Schools in Philadelphia.

If you have in hand the Instructor's Guide to the program, or Unit 1 entitled Training Program Introduction and General Study Plan Guide, you will have sufficient introduction to the nature and purposes of the training program. If you do not have access to one or both of these items, the following paragraphs will introduce you to this unit of the program.

This unit was designed for use by anyone holding a position calling for leadership in planning and conducting local educational change programs. This means school district leaders - central office administrators, building principals, curriculum specialists, or teachers involved in change project teams. Also it means graduate students in curriculum, administration, or supervision. In addition, curriculum specialists or field personnel of state education departments or other educational agencies may find the unit of value in their work with school districts - as in the conduct of workshops involving local school personnel.

The unit can be studied on a wholly self-instructional basis, or with an instructor's direction. It requires about 6 to 8 hours of study time. You will recognize the theme of the unit - enquiry (or problem solving) - as the central purpose of curriculum reform during the past quarter-century.

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INTRODUCTION

What is this unit about?

This unit deals with enquiry - the central theme of efforts to build new curricula and instructional procedures during the past two decades. Every educational leader needs to know about this approach to reforming curriculum and instruction as a basis for helping school systems respond to it.

The curriculum in the major areas of the elementary and secondary schools came under sharp attack in the 50's with the strongest concern initially being for national security as related to the preparation of mathematicians, scientists, and engineers. The Soviet Union appeared to have passed us in these areas and the country's survival seemed threatened. The chief criticisms were that the curricula in mathematics and science were out of date, over-emphasized teaching skills or facts rather than powerful ideas, and failed to teach students an understanding of the methods of enquiry or "discovery" used by mathematicians or scientists in gaining new knowledge in their fields. Somewhat later, similar criticisms were made of the traditional curricula in the social studies.

As a result of these criticisms, and with heavy financial support from the Federal Government and private foundations, scores of curriculum development projects were established. An important feature of nearly all of these projects has been the inclusion of leading scholars, mathematicians, or scientists alongside educators as members of the project teams.

On the next page you will find a list of some of the best known curriculum development projects, or the curricula they have produced. The list identifies only a small fraction of curriculum projects or products that have focused on teaching enquiry. How many of those listed are you familiar with?

Enquiry-Focused Curriculum Projects or Curricula

General

Productive Thinking Program (Elementary) - Crutchfield and Covington
Creative Problem-Solving Program - Sidney J. Parnes

Science - Elementary

Conceptually Oriented Program In Elementary Science (COPES) - Morris H. Shamos
Inquiry Development Program in Physical Science (IDP) - J. Richard Suchman
Science - A Process Approach (SAPA) - John Mayor of AAAS
Science Curriculum Improvement Study (SCIS) - Robert Karplus
Elementary Science Study (ESS) - Frank Watson, Educational Development Center
Elementary School Science Project (Astronomy) - Myron Atkin and Stanley Wyatt

Science - Secondary

Earth Science Curriculum Project (ESCP) - American Geological Institute
Introductory Physical Science (IPS) - Educational Development Center
Biological Sciences Curriculum Study (BSCS) - Joseph H. Schwab
Chemical Bond Approach Project (CBA) - Laurence Strong
Physical Science Study Committee Physics (PSSC) - Educational Services, Inc.
Harvard Project Physics

Mathematics - Elementary

Greater Cleveland Mathematics Program
The Madison Mathematics Project - Robert Davis
University of Illinois Arithmetic Project - David Page
Nuffield Mathematics Project
University of Illinois Committee on School Mathematics (UICSM) - Max Beberman

Mathematics - Secondary

School Mathematics Study Group (SMSG) - E.G. Begle
University of Maryland Mathematics Project - Robert Gagné
Secondary School Math Curriculum Improvement Study - Howard Fehr

Social Studies - Elementary

Our Working World - Lawrence Senesh
Man: A Course of Study - Jerome Bruner, Educational Development Center
Curriculum Development Project in Social Studies - Hilda Taba

Social Studies - Secondary

Harvard University Social Studies Project - Donald Oliver and James Shaver
High School Geography Program - Association of American Geographers
Carnegie-Mellon University Social Study Curriculum Project - Edward Fenton
Anthropology Curriculum Study Project - American Anthropological Association

This unit offers study of enquiry as a type of educational goal and examines ways in which the teaching of enquiry is becoming a key emphasis in elementary and secondary schools.

What does this unit offer you?

What you will learn from this unit obviously depends on what you already know about enquiry and enquiry-focused instruction. Also it depends on what sorts of knowledge or competencies involving enquiry you wish to possess. Here are the topics or competencies covered in this unit:

1. Definition and requirements for enquiry-focused instruction

   What is enquiry and what are the essential requirements for any instance of enquiry?

2. A rationale for enquiry-focused instruction

   What reasons can be offered for placing an emphasis on teaching students how to conduct enquiries?

3. The relations between ideas and enquiry

   What roles does theory in the form of ideas (concepts and principles) play in the conduct of enquiries?

4. Models for enquiry

   Outline the steps or stages in conducting an enquiry, placing emphasis on a general problem-solving model.

5. Analyzing curricula in terms of enquiry

   This part of the unit offers practice in using an enquiry check-list to analyze and evaluate the extent to which a curriculum is designed to teach or employ enquiry.

6. Analyzing instruction in terms of enquiry

   This part of the unit calls for using an enquiry checklist to analyze and assess the extent to which instructional procedures teach enquiry or foster students' learning subject matter through enquiry.

7. Assisting a school district in introducing enquiry-focused instruction

   This section of the unit offers general guidelines for assisting a school system that wishes to increase its emphasis on teaching enquiry.

UNIT STUDY PLAN

Before beginning study of this unit, you should determine how intensively you want or need to study each objective. After a careful diagnosis of your needs and present attainments, if you judge that study of some of the unit objectives is unnecessary, you are free to omit them from your study plan.

Below is a guide for arriving at your study plan, either with help from your instructor (if you have one) or on your own. The guide calls for a four-step procedure: assess your needs to study the unit objectives, decide how to study them, assess your mastery of the unit objectives after study of the unit, and evaluate the unit.

1. Personal assessment of needs to study the unit. First, turn the pages of the unit quickly to acquaint yourself with the objectives and the unit contents. Twenty minutes should be sufficient for skimming the unit for this purpose.

Next, perform the Pre-Assessment Exercise that follows to obtain a basis for estimating your present level of mastery of the unit objectives. In doing the Pre-Assessment Exercise, use it simply as a way of determining what parts of the unit you need to study. It is not expected that you will pass the Pre-Assessment Exercise, though you may find that you can answer some of the questions adequately before studying the unit.

When you have completed the Pre-Assessment Exercise, check your answers with the Pre-Assessment Exercise - Answer Key at the end of the unit. Keep in mind that this exercise is not a test but is for your use in determining which parts of the unit will require the greatest amounts of your time and concentration.

PRE-ASSESSMENT EXERCISE - UNIT 5

Directions: This pre-assessment exercise serves two purposes - it gives you the opportunity to demonstrate mastery of some unit objectives before studying the unit, and it orients you to the unit as preparation for studying it.

Feel no obligation to answer a question. It is not expected that you will necessarily be able to answer any of the questions. However, if you can give a fully adequate answer to a question on this pre-assessment, you have no need to study that part of the unit to which the question refers.

Probably you will need no more than one-half hour to complete this exercise. When you complete it, turn to the Pre/Post Assessment Exercise - Answer Key at the end of the unit to check your answers. Then turn to the page following this Pre-Assessment Exercise to continue with your unit study plan.

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1. Define enquiry and indicate its essential components.

2a. Why should schools emphasize teaching all students how to enquire?

2b. Should schools seek to have students acquire knowledge and skills in a curriculum area mainly through conducting enquiries? Explain your answer.

3. How are ideas (concepts and principles) related to enquiry?

4. List key steps or stages in the enquiry process.

5. What features would you look for in a curriculum to determine the extent to which it teaches enquiry?

6. What features would you look for in the conduct of instruction to determine the extent to which it teaches enquiry?

7. What should you be prepared to do if called upon to help a school district set about to improve instruction in enquiry within any curriculum area?

Note: To check your answers, turn to the Pre/Post Assessment Exercise - Answer Key at the end of the unit.

Having completed the Pre-Assessment Exercise, you (with your instructor, if you have one) should check your answers with those given in the Pre/Post Assessment Exercise - Answer Key to be found at the end of the unit. Compare the quality and detail of your answers with those offered in the Answer Key. There is no one right answer to any of the questions but rather key points that are required for an adequate answer, with these points stated in your own words. The Answer Key probably contains fuller answers to most of the questions in the exercise than you can give before studying the unit.

In the following table, you are asked to check the estimates you (and your instructor) make of your level of mastery of each objective or part-objective. Check HIGH if you judge your answer to be right on target and in adequate detail. Check MODERATE if you believe your answer to be good but lacking some points needed for a fully adequate answer. Check LOW if you find your answer to be inappropriate or incomplete, or if you did not answer the question.

After checking your level of mastery of each objective, check at the right whether the objective requires merely review, or careful study. It is not a sound procedure for you to study the Answer Key as a way of learning answers to items on the Pre-Assessment Exercise. Instead, you should study the unit materials since they are meant to prepare you to give an adequate answer based on an understanding derived from doing the readings and practice exercises.

OBJECTIVE	TOPIC	PRESENT MASTERY H	M	L	REVIEW ONLY	NEED TO STUDY
1.	State a definition of enquiry and list its essential requirements	___	___	___	___	___
2.	State a justification for placing emphasis on enquiry-focused instruction	___	___	___	___	___
3.	State the relations between ideas (concepts and principles) and enquiry	___	___	___	___	___
4.	Outline the steps in a model for conducting enquiry or problem solving	___	___	___	___	___
5.	Analyze curricula in terms of enquiry, using an enquiry checklist	___	___	___	___	___
6.	Analyze instruction in terms of enquiry, using a list of enquiry features	___	___	___	___	___
7.	Outline how you would help schools introduce enquiry-focused instruction	___	___	___	___	___

2. Study procedure. In studying the unit, you will gain by doing the objectives in the order in which they appear since each part of the unit assumes a level of understanding based on the previous parts. It is a good idea to at least skim each part of the unit even though you judge that you already have mastery of some parts of it.

You may wish to study all or part of the unit with one or more fellow students. Also, your instructor may elect to conduct group sessions either to introduce or review parts of the unit. And, of course, you could study the unit entirely independently.

You probably will take from 6 to 8 hours to study this unit. When you complete your study, you will find the Post-Assessment Exercise at the end of the unit. Also included with the unit is an evaluation form (at the very end). It will be helpful if you complete and return this form to the address given as an aid in making any revisions of the unit.

Objective 1. State a definition of enquiry and list its essential requirements.

What is enquiry?

Enquiry refers to the processes of thinking and acting involved in seeking a solution to any sort of problem where the word problem refers to a need, a difficulty, or a purpose (or wish).

A variant spelling of the term is inquiry. The term problem solving can be used as a synonym for enquiry. Other terms referring to broad types or processes of enquiry are investigation, research, discovery, and creativity.

What are essential requirements for enquiry?

The following three are offered as minimal requirements for any instance of enquiry:

1. The enquirer confronts a problem (need, difficulty, or purpose).

2. The enquirer must select or devise an approach to solving the problem, then try that approach. Using recipes is not enquiry.

3. The enquirer must proceed largely on his own in seeking a solution to the problem. Turning to an authority for the solution is not enquiry.

What are examples of enquiry in school subjects?

Examples of enquiry in reading and the language arts are these: writing a précis that digests any sort of written material; preparing a speech; writing a poem; analyzing any literary work; comparing two literary works; or analyzing different individuals' reactions to a literary work.

Enquiries in social studies include conducting an opinion poll; deciding how to vote in an election; analyzing one's own attitudes toward members of minority groups; or comparing one's community with some other community in terms of such factors as institutions, roles, norms, and communication patterns.

An enquiry in mathematics might consist of applying one's knowledge to the solution of a mathematical puzzle, or it might call for figuring out a number of ways of solving the same problem.

Enquiries in science might consist of planning and conducting experiments, or applying knowledge of scientific principles in designing a solution to a technological problem.

In the areas of art or music, enquiries would call for studying creative products, or for oneself creating some product.

Exercise 1 that follows offers you a check on your understanding of this objective.

EXERCISE 1 - WORKSHEET

Directions: Respond to the questions in this exercise for practice and as a check on your understanding. The Answer Key for this exercise is on the page that follows.

---

1. Complete the two sentences below to practice the definitions given on Page 11.

   Enquiry refers to the processes of _____

   that are involved in _____.

   According to the definition offered, the word problem can refer to

   a _____, a _____, or a _____.

2. Which of the following instances illustrates enquiry by satisfying the set of essential requirements offered on Page 11? (Caution: The process of enquiry does not need to be carried out completely or successfully to illustrate enquiry. Also, there are times when one turns to expert sources of information as part of conducting an enquiry. The critical point concerns who is doing the thinking, planning, deciding, etc. Another point: students can get together to conduct group enquiries where different students make different contributions to the group effort.)

   a. A teacher assigns the multiplication problem, 1946 X 271. Using his knowledge of the multiplication table and of the algorithm involving carrying, etc., the student obtains the correct answer.

      Check: This illustrates enquiry____ This does not illustrate enquiry____

   b. A student helps plan a group project in library research on pollution, accepts the assignment to prepare a report on pollution of inland lakes, asks the librarian for help in locating files of periodicals, then finds and summarizes a number of articles on his topic.

      Check: This illustrates enquiry____ This does not illustrate enquiry____

   c. A student assists his instructor in carrying out a public opinion poll by making house calls to fill out a questionnaire provided by the instructor.

      Check: This illustrates enquiry____ This does not illustrate enquiry____

   d. A student, assigned the task of conducting an opinion poll, examines several methods described in a handbook and selects the one he considers best suited to his purpose, then follows that method.

      Check: This illustrates enquiry____ This does not illustrate enquiry____

Check your answers using the Answer Key on the next page.

EXERCISE 1 - ANSWER KEY

Explanation: Answers to the fill-in questions are given directly on Page 11. Answers to parts a-d of Question 2 are given below, with brief explanations.

Question 2a. Not enquiry. Getting the answer to this "problem" does not require problem solving in the sense of selecting or devising a solution. Solving the problem is merely exercise for the student referred to.

Question 2b. Enquiry. Note that the student carries out planning and analysis activities in doing his part of the group project.

Question 2c. Not enquiry. In this example, the student merely uses the procedures and questionnaire prepared by his instructor.

Question 2d. Enquiry. Now the student has some genuine problem solving to do in the process of analyzing a number of polling methods and choosing one suiting his purposes.

Objective 2. State a justification for placing emphasis on enquiry-focused instruction and indicate its limitations.

Reasons for an emphasis on enquiry

Two chief reasons have been offered as justifications for teaching all students how to conduct enquiries rather than merely learning what they are told by textbooks and teachers, or rather than merely learning facts and skills in the subjects they study. The first reason involves a conception of education as being primarily a matter of becoming competent in interpreting and controlling one's experiences. This is the essential position of John Dewey's educational philosophy. In Experience and Education (New York: Collier, 1963) Dewey stated: "The ideal aim of education is creation of power of self-control." (p. 64) In the same volume he proposed utilizing "scientific method as the pattern and ideal of intelligent exploration and exploitation of the potentialities inherent in experience." (p. 86) In other words, Dewey sees methods of enquiry as the heart of education inasmuch as they give the individual the power to interpret and control his experiences.

The second reason for a stress on teaching enquiry takes account of the very rapid and unpredictable changes in knowledge, in technologies, and in social forces. Great world-wide problems threaten to overwhelm us: overpopulation, the using up of natural resources, pollution, automation and job obsolescence, rising crime, and the threat of nuclear war. In this world of constant change, a person must become capable of meeting ever new demands, of solving a multitude of problems confronting him. Learning how to conduct enquiries, that is, to solve problems, thus must become a critical emphasis in the educational program.

An excellent statement about these changing demands on education is an article by Robert M. Hutchins, President of the Center for the Study of Democratic Institutions, entitled "Are We Educating Our Children for the Wrong Future?" (Saturday Review, September 11, 1965) Hutchins sees two central

purposes of education - "to educate for an undecipherable future," and "to prepare for a world in which work has lost its significance." With respect to the first of these purposes, Hutchins points out that the whole world is committed to the highest possible rate of change and about all we can know about the future is that it will not be like the present. With respect to the second purpose, Hutchins calls attention to the impact of automation on jobs and notes that the familiar relation between production and jobs is ceasing to exist. Education for being human, for using leisure time well, becomes increasingly important as the emphasis on education for work declines. The central point Hutchins makes is that a truly educated person "is ready for anything" because he is prepared "to meet any new problem he has to face."

Two other reasons can be offered for an emphasis on enquiry-focused instruction. This approach, since it calls for applying knowledge to the solution of academic and practical problems, makes knowledge more usable than if it were acquired without relation to solving problems. Finally, it is generally true that students' motivation to learn is increased when they engage in enquiry rather than learning by methods such as drill, memorization, or reading for "understanding."

Limitations of enquiry-focused instruction

Two cautions should prevent going overboard concerning enquiry-focused instruction. The first is that learning to enquire is different from learning by enquiry. Three sound reasons can be given for learning to enquire: gaining an understanding of how knowledge is obtained in a given field of enquiry such as sociology, becoming able to evaluate conclusions drawn by others as the result of their enquiries, and becoming able to conduct one's own enquiries about matters of personal interest or concern. But learning to enquire is

very different from learning what one comes to know in a field such as biology or economics through conducting enquiries. A person could not hope to acquire through enquiry more than a tiny fraction of the knowledge of a field that he could acquire by reading, by being told, or by being shown. A good discussion of this point can be found in the article, "Discovery or Invention?" by J. Myron Atkin and Robert Karplus (Science Teacher, 1962, 29, 45-51). Invention, they hold, refers to the original introduction of a new concept, principle, or relationship. Discovery, on the other hand, they would have refer to "the subsequent recognition of the concept's usefulness," that is, to identifying instances where the concept (or principle) applies. It is discovery in this sense that students should be taught to achieve. The most systematic analysis of discovery learning is Learning by Discovery: A Critical Appraisal edited by Lee S. Shulman and Evan R. Keislar (Chicago: Rand McNally, 1966).

Of course students are not limited to discovering instances where concepts or principles they have been taught can be applied to explaining phenomena. Students also can "discover" concepts or principles they have not been taught. An example, where you are called upon to be the discoverer, is the following problem where your task is to discover the rule and fill in the next two numbers in the series:

1 2 5 14 ___ ___

In solving this sort of problem, or puzzle, you will notice that you must examine the problem and the requirements for solving it, develop hunches or hypotheses about the rule for the sequence, then test each hunch with the numbers given until you find one rule that fits. Filling in the missing numbers then applies the rule you have discovered. If you would like to do

another similar problem, here's one where your task is to find the sum of the first 20 odd numbers. The table below gives you the answers for the first 4 odd numbers and the basis for discovering the rule that will make getting the answers for odd numbers 5-19 unnecessary. Can you find the rule?

# of Odd Number	Odd Number	Sum
1	1	1
2	3 (+1)	4
3	5 (+4)	9
4	7 (+9)	16
5	_____ ?	___ ?
⋮		
20		_____ ?

The first limitation to enquiry-focused instruction just presented is that learning by enquiry is a very time-consuming and uncertain process and cannot be employed successfully in teaching the great bulk of what a person learns in a subject such as science, mathematics, or social studies. The second limitation is that many things need to be learned through drill or memorization rather than through a process of analysis or discovery. This is the case with such things as the basic number facts and operations, vocabulary, spelling, and the alphabet. Efficiency in learning such basic tool skills cannot be achieved through enquiry. However, enquiries can give rise to needs to learn skills (such as how to use a microscope) and skills, once learned, can be employed in conducting enquiries.

Objective 3. State the relations between ideas (concepts and principles) and enquiry.

Why ideas are essential for enquiry

Ideas are the critical ingredients of thinking and thinking is essential for enquiry or problem solving. In conducting enquiries, a person needs to analyze the problem into components or requirements; needs to have ideas (hypotheses) concerning solutions; and needs to test these ideas to determine whether they result in a solution.

A key word is theory that consists of ideas about the relationships between or among variables. A variable is any aspect (component, feature) of a situation that can vary either by being present sometimes and absent sometimes, or by being present to different degrees at different times. We label variables with concepts or terms such as temperature, pressure, distance, satisfaction, hunger, etc. Statements about relationships between or among variables are called hypotheses if not tested; principles (rules, laws) if tested and found to be true.

Exercise 2 offers you a way of checking your familiarity with these terms associated with the relations between ideas and enquiry. If you showed mastery of this objective on the Pre-Assessment Exercise, you may elect to skip this exercise.

Following the exercise, beginning on page 21, you will find a description of one approach to teaching students to generate and test ideas in conducting enquiries. If you wish to read further on using ideas in problem solving, an excellent reference is Robert M. Gagné, The Conditions of Learning, Chapter 8 (New York: Holt, Rinehart and Winston, 1970).

EXERCISE 2 - WORKSHEET

Ideas Involved in Enquiry-Focused Instruction

Directions: To check your knowledge of terms for ideas related to enquiry-focused instruction, fill in the blanks below with the appropriate words or numbers. In some cases in Part A, more than one word is appropriate; you can write in one, or more than one, word.

Part A

Any component or feature of a situation is _____

An untested statement of a relationship between or among features of a situation is _____

An established relationship between or among features of a situation is _____

A general word covering statements on features and relationships in a situation is _____

Part B

Assume that a school system has done a study comparing the effects of (1) heterogeneous grouping and (2) homogeneous grouping in the elementary school on (3) self-concepts of low-achieving students. Assume that the initial expectation was that (4) homogeneous grouping would produce the more-favorable self concepts. Assume that (5) it was found that heterogeneous grouping produced the more-favorable self concepts. In the spaces below, fill in the appropriate numbers, 1-5.

Variables in the situation included in the study were Nos. _____

The principle involved in the study was No. _____

The hypothesis involved in the study was No. _____

EXERCISE 2 - ANSWER KEY

Ideas Involved in Enquiry-Focused Instruction

Explanation: The answers offered below are based on the material given on page 18 of this unit. In Part A, the preferred answer is given first, followed by other acceptable answers in parenthesis. You may have entered other answers that are appropriate.

Part A

Any component or feature of a situation is a variable

An untested statement of a relationship between or among features of a situation is an hypothesis

An established relationship between or among features of a situation is a principle (rule, law)

A general word covering statements on features and relationships in a situation is theory

Part B

Variables in the situation included in the study were Nos. 1,2,3

The principle involved in the study was No. 5

The hypothesis involved in the study was No. 4

The Case of Jim and Lila; or the Great Thinking Mystery

(This article is from the Carnegie Corporation of New York Quarterly, October 1965; Vo. 13, No. 4. It describes the Productive Thinking Program.)

Richard S. Crutchfield, professor of psychology at the University of California at Berkeley, looks and acts like anything but a revolutionary, but he is one, educationally speaking. He holds the following uncommon beliefs: first, that it is possible to teach children to think creatively and to bring their general intellectual skills to bear on solving problems; second, that it is possible to do this directly rather than in the indirect, not to say sideways or backward, manner in which educators have traditionally approached the matter when they have approached it at all; and third, that an effective medium for doing so is the very one that seems on the face of it to be antithetical to the stimulation of creativity: programed instruction.

And he is well on the way to proving his points.

"The schools give virtually no direct and systematic training in thinking as such," Crutchfield remarked recently. "The only nod they make in this direction is to teach a little logic--and of course logic is an ineffectual way of teaching youngsters to think creatively, to be inventive, to generate ideas, to form hypotheses, to be alert to cues and clues."

Crutchfield is anything but antilogical; in fact, it was logic which led him to the idea of putting the horse before the cart so far as the transferability of general thinking skills goes. From the beginning of time, most educators have done the reverse. The idea has been, despite the paucity of evidence to support it, that there is a transfer of skills from one kind of intellectual activity to another and also to general thinking. Thus, we have all heard a hundred times that "mathematics teaches you to think." Although Crutchfield and his colleague Covington believe that recent curricular reforms in math and other subjects do

have the effect of stimulating real thinking, they believe that in general the transfer of skills from one discipline to another has been haphazard at best. Anyway, why try to go from the particular to the general? Instead of trusting a youngster to transfer the way he has learned to tackle a problem in algebra from that to other subjects, why not teach him a variety of ways to attack problems and hope that he will apply them to all parts of the curriculum?

The approach Crutchfield, Covington, amd members of their group have taken is to develop a set of self-instructional materials to be used by fifth and sixth graders. The sequence now consists of sixteen booklets, each presenting a problem on which the child works. The problems are cast in a continuous story form, presented partly in cartoon strips. The research is supported by a Carnegie grant, and probably represents the Corporation's first venture into the comic book line.

The protagonists of the series are Jim and Lila Cannon, a brother and sister who are living for a year with their Uncle John, a high school science teacher who moonlights as a detective. Jim and Lila embark on solving some mysteries on their own: the puzzling disappearance of money from a river boat, some strange goings-on in a mansion that is said to be haunted. Under their Uncle John's benevolent but shrewd tutelage, Jim and Lila are led to generate many ideas about what "could" have happened in a given case, to check these possibilities against the known facts, to form new hypotheses as new facts are learned, to ask relevant questions, to be sensitive to odd or discrepant happenings, to reformulate the problem when they are stuck so that they can see it in a different way and thus generate even more new ideas. In each case, Jim and Lila finally come up with the solution, though not without experiencing the anxiety and frustration that attend all efforts to think creatively.

Each mystery forms a complete lesson in a booklet, and each child works on it at his own pace—one of the great advantages of self-instructional materials. At appropriate places there is a chance for each reader to put down some of his own ideas after seeing Jim and Lila in action: "How would you state the problem?" or "Can you think of some other things that could have happened?" On the next page, the child gets some immediate feedback, another advantage of programed instruction, except that instead of there being only one correct response, as is true of orthodox programing, there are several suitable examples, with the implication that there could be even more.

To date, the materials have been used with more than 250 school children in the San Francisco Bay Area; there were also control groups of similar size, matched for age, sex, intelligence, and performance on some pretests for measuring creative thinking proficiency. Following the end of the training period (which at the rate of approximately thirty minutes per booklet amounted to only about eight hours in all), both groups were given a long battery of posttests to measure changes in their proficiency at creative thinking.

When psychologists find an obvious relationship between one thing and another they call it a "significant correlation," and that is fairly strong language for them. In this case, they can stick to their terminology and we will use our own, which is simply to say that the results are remarkable.

On various problem-solving tests—some with problems similar to those used in the training booklets and others quite different in form and content—the trained children were able to generate about twice as many acceptable ideas as the controls; the rated quality of their ideas surpassed that of the controls by an even greater margin; they were more sensitive in noticing both significant clues and factual discrepancies; and above all, they achieved more actual solutions to the problems by margins ranging up to three to one.

Just as important, since we have been speaking of "transfer" and "generalizing," the trained children showed similar superiority in tests that were totally unlike anything included in their lessons. When asked to think of as many unusual uses for a tin can as they were able to, for example, the trained children outperformed the controls markedly both on sheer volume of ideas and on the originality of them, and they did similarly well when asked to think of as many ways as possible to make a toy dog more fun to play with.

It should be stressed that the two groups were carefully matched, and that although there is a substantial correlation between intelligence and performance on such problem tests, children of lower IQ's who have been trained will now surpass untrained children of higher IQ's. For example, the training program anabled a child with an IQ of 92 to surpass a control with an IQ of 123. Furthermore, when tested on new problems six months later, the trained children continued to surpass the controls by approximately a two-to-one margin.

.....

(The article continues. However, the gist of it for the purposes of this unit is contained in the excerpt offered you. An important point the authors of the program make in the conclusion of this article is that the eight hours of study of the booklets probably did not teach new thinking skills as much as they sensitized students to use skills they already possessed.)

Objective 4.	Outline the steps or stages in a model for conducting enquiry or problem solving.

Introduction

Many models for the conduct of enquiry or problem solving have been presented. Some are meant to be general, applying to the process of solving any sort of problem. Some are designed for solving certain types of problems, such as testing a scientific hypothesis with an experiment using a control group.

A famous general model is that offered by John Dewey in How We Think (Boston: Heath, 1910). His model, in four stages or steps, calls for the presentation of the problem, defining the problem, formulating hypotheses related to a solution, then verifying the hypotheses until one achieves the required solution.

The model presented in this unit is a general one and consists of eight steps or stages. It is built on the definition of enquiry presented above on page 8. The following paragraphs introduce the model.

Problem solving is the process of conducting any activities (including thinking) that are directed toward accomplishing a purpose (meeting a need, satisfying a wish, or resolving a difficulty) provided that the problem solver does not already know how to arrive at a solution and must either identify (choose) or create a procedure for reaching a solution.

Many instances of so-called problem solving do not fit under the definition since they do not require any choosing, planning, or creating; rather, they call merely for applying a procedure (formula, recipe) one already knows. For example, the answer to the question "What is 11 times 12?" may immediately come to mind because one has memorized it; or one can get the answer by using the familiar multiplication algorithm to figure it out; or one can look up the

answer in a printed multiplication table; or one can ask another person for the answer. None of these procedures requires true problem solving.

You might illustrate problem solving by inventing a new method of getting the product of 11 times 12. Suppose you used your knowledge of addition and simple multiplication. You might proceed this way: 11 is made up of three 3's and one 2; 3 X 12 is 36 and 2 X 12 is 24; 11 X 12 is 36 + 36 + 36 + 24 = 132. But, if you had been taught this method of getting a product, you would not be problem solving since you wouldn't have to choose or create a procedure for getting the answer.

There is no official set of components or stages in the problem-solving process. However, the list of eight components given here is offered as one that covers the process of solving any sort of problem quite well. Study the list, the functions of each component, and the illustration given so that you will be prepared to perform Exercise 3 that requires you to illustrate each component of the model in solving a problem assigned you.

A General Problem-Solving Model

In the model presented below, each step or stage is given a title, then is amplified in terms of its functions and an illustration of those functions.

COMPONENT

1. Identifying a problem

   Functions: Realizing a need, recognizing a difficulty, or having a wish or purpose.

   Illustration: A school administrator holding a masters degree decides that he wishes to obtain a doctorate in education.

2. Analyzing the problem

   Functions: Specifying the criteria a solution needs to meet and specifying the requirements for satisfying those criteria.

   Illustration: The doctoral program entered must be in a "prestige" university, it must not require full-time attendance, and it must not require getting another job and moving the family. Meeting these criteria calls for gaining admission to a doctoral program at one of the "name" universities within about 150 miles from home, and being able to attend classes mainly evenings, weekends, and during summer vacation.

3. Searching for a solution

   Functions: Identifying, analyzing, and evaluating alternative potential solutions; or creating one or more potential solutions.

   Illustration: A search for doctoral programs meeting the above requirements is made through study of catalogs, telephone interviews with university officials and professors, and inquiries of friends who have advanced degrees from nearby universities. Information is obtained about a doctoral program offered by an "open university" 500 miles away that requires only summer attendance plus an approved dissertation advisor near home. The alternatives identified are analyzed and evaluated. For the alternatives judged most desirable, information is sought on the likelihood of being admitted.

4. Choosing a solution

Functions: Matching needs (wishes, difficulties), alternative solutions, and resources available (money, time, etc.) to pick the best among the alternative solutions.

Illustration: After checking the preferred alternative doctoral programs available against one's schedule and bank account, the decision is made to apply to two of the nearby universities and to the open university, and to enroll at the one ranking highest in preference order among those accepting the application. All three offer admission and a nearby university is chosen.

5. Preparing to try the solution

Functions: If the solution chosen is ready for use, this stage of problem solving may require only making specific preparations to put it into effect (as by preparing a schedule, informing people involved, etc.). However, often a solution chosen needs to be built or modified for use and often there is the need to design a plan for implementing the solution.

Illustration: Preparing to begin study in the doctoral program may require meeting with program advisors, selecting courses, and undertaking a carefully-planned library project to build a background of knowledge in the area that very likely will be chosen for the dissertation.

6. Trying the solution

Functions: The task now is to implement the solution chosen with the purpose of resolving the problem. The objective is to obtain full and effective implementation of the chosen solution; otherwise, a failure to solve the problem may be due to faulty implementation rather than to shortcomings in the solution chosen.

Illustration: This phase involves studying in the doctoral program. Completing the phase normally takes years. Fully implementing the doctoral program requires that the student commit himself to it at a level that will meet the university requirements as to amount and quality of work.

7. Evaluating the solution

Functions: Determining whether the problem has been resolved. If it has not been fully resolved, to what extent has the solution been successful? Also, can the failure to resolve the problem be blamed on incomplete implementation of the solution chosen?

Illustration: Judging the success of the doctoral program can be done on a piece-by-piece basis to assess progress toward the goal of obtaining a doctorate. Are the courses taken contributing toward the final goal? (Such periodic evaluations could provide the basis for shifting to another university if the program were found unsatisfactory.) Obviously, the ultimate evaluation of the program would occur at the end: Was a doctorate granted? Did having the doctorate result in job improvements and advancement in the educational profession?

8. Deciding on a post-tryout course of action

Functions: In case the solution was successful, deciding whether to terminate action, continue the solution in force, or seek to spread its use. In case the solution was unsuccessful, deciding whether to give up the effort, or try to improve the implementation of the solution, or re-cycle to identify and choose another solution.

Illustration: In the event the doctoral program is judged to be progressing satisfactorily, it will simply be continued. If it is completed and terminates in a doctorate, that will obviously terminate the problem-solving process. In case progress is not satisfactory, or the student leaves the program, or a doctorate is not granted, it may be necessary to improve the implementation of the solution chosen or to seek another solution.

EXERCISE 3 - WORKSHEET

Preparing and Giving a Talk

Directions: In this exercise, you are given the problem you are to plan to solve. Fill in these worksheets with the specific things you would do under each of steps 2-8. When you complete filling out your worksheets, check your work by referring to the answer key that follows. Remember, the material given on the answer key is meant to help you understand the problem-solving process. There are no right or wrong answers except that some answers can fail to show understanding of the steps involved.

---

1. Identifying the problem
   You are to give a talk to the elementary principals of a school district introducing them to the purposes and make-up of the British open-classroom plan.

2. Analyzing the problem

3. Searching for a solution
   CUE: Think of different ways you could organize and conduct your talk.

4. Choosing a solution
   CUE: This calls for deciding among alternative ways of putting your talk together.

5. Preparing to try the solution
   CUE: If trying the solution is giving the talk, what prepares you for this?

6. Trying the solution

7. Evaluating the solution

8. Deciding on a post-tryout course of action
   CUE: If your talk didn't go over well, what to do about it? Or, if the talk evoked marked interest in the program, what could you do next?

Reminder: When you complete this exercise, check your work against the ANSWER KEY.

EXERCISE 3 - ANSWER KEY

Preparing and Giving a Talk

1. Identifying the problem

   The answer is given on the worksheet for the exercise.

2. Analyzing the problem

   What should be the purpose of my talk: to give the principals a basis for deciding whether to adopt the open classroom, to induce them to adopt it, or merely to let them know the program exists?

   What backgrounds have the principals that will tell me how to set the talk? Should I assume they have heard about open education? Should I assume they will need to be convinced that such programs as the open classroom are worthwhile?

3. Searching for a solution

   I could merely present a description of the program.

   I could tell them what the program could offer a school.

   I could tell them what is required to implement the program.

   I could tell them what results the program has achieved in different settings.

   I could use A/V materials such as transparencies shown by an overhead projector.

   I could use filmstrips to offer a visual presentation of the program.

4. Choosing a solution

   This step calls for deciding which of the alternatives considered under 3 above are to be adopted. Thus, you might decide to describe the program, tell what it can offer, tell what results it has achieved, and present these points with the visual support offered by transparencies.

5. Preparing to try the solution

   This calls for outlining the talk or writing it out, then for rehearsing it either by yourself or trying it on a friend. The point is to get ready to deliver the talk.

6. Trying the solution

   This step is accomplished by giving the talk.

7. Evaluating the solution

   This step calls for judging how successful your talk was on the basis of spontaneous reactions from the audience (questions asked, clapping, compliments at the end of the talk, etc.), on the basis of reactions requested (as from a questionnaire you asked the audience to fill out), or on the basis of later evidence such as expressions of the desire to adopt the plan.

8. Deciding on a post-tryout course of action

   Your course of action should depend on what happened re Step 7. Is a follow-up needed, or should you rest on your oars and wait for further responses?

Other models of enquiry

The general problem-solving model you have just studied gives you a set of steps that apply to any sort of academic or practical problem. Below, for comparison purposes, are several other models having a good deal in common with the model presented above, though the number and wording of steps vary considerably.

Many people believe that the most basic method of enquiry is "the scientific method." Scientists, however, generally reject this term, insisting that there is no one scientific method but rather a large number of methods involving enquiry processes occurring in different combinations and sequences. The approach used in Science - A Process Approach (SAPA), an elementary science curriculum developed by the American Association for the Advancement of Science, illustrates this focus on enquiry processes rather than just one problem-solving model. These processes are taught: observing, classifying, using numbers, measuring, using space/time relationships, communicating, predicting, inferring, defining operationally, formulating hypotheses, interpreting data, controlling variables, and experimenting.

Crutchfield and Covington, whose Productive Thinking Program was described under Objective 3 of this unit, list the following "broad strategies of productive problem solving":

Formulating and clarifying the essentials of the problem

Laying out and following an orderly plan of attack on the problem

Maximizing the number and variety of ideas, including unusual ones

Systematically exploring for ideas by first listing main ideas and then searching for the particular ideas which stem from each of them

Keeping an open mind by refraining from jumping to conclusions about the correctness of ideas until sufficient data are available to test them

Attending to facts and seeking new facts as needed to evaluate hypotheses

Trying to look at the problem in a new and different way when blocked at a "dead-end."

A valuable sourcebook on enquiry models is Models of Teaching by Bruce Joyce and Marsha Weil (Englewood Cliffs, New Jersey: Prentice-Hall, 1972). Chapter 4 of that work describes a model for enquiry in the social studies developed by Massialas and Cox. Chapter 7 describes the approach to teaching inductive thinking developed by Hilda Taba. Chapter 8 presents the "inquiry training model" developed by J. Richard Suchman. Chapter 9 presents the model of enquiry employed in the Biological Sciences Curriculum Study that produced an enquiry-focused secondary biology curriculum.

The following analysis of enquiry in the social sciences by Grannis illustrates dramatically how different "levels of thinking" in the process of enquiry can occur in different orders.

The Process of Inquiry in the Social Sciences

Joseph C. Grannis

(from the Social Studies Curriculum Guide of the Franklin and Estabrook Schools in Lexington, Massachusetts.)

The curriculum stems in part from our ideas about the process of inquiry in the social sciences. One way of interpreting this is in terms of various levels of thinking that are involved in the social sciences. We can specify six levels of thinking as follows:

a. Principles of validity and reliability, or theory of knowledge.

b. Basic substantive assumptions and questions.

c. Concepts.

d. Generalizations and hypotheses.

e. Specific inferences and predictions.

f. Facts and data.

In order to illustrate the application of these different levels, let us analyze the following description of thinking in a fifth grade class, where the pupils were studying the geography of the North Central States.

> We hit upon the happy idea of presenting this chunk of geography not as a set of knowns, but as a set of unknowns. One class was presented blank maps, containing only tracings of the rivers and lakes of the area as well as the natural resources. They were asked as a first exercise to indicate where the principal cities would be located, where the railroads, and where the main highways. Books and maps were not permitted and "looking up the facts" was cast in a sinful light. Upon completing this exercise, a class discussion was begun in which the children attempted to justify why the major city would be here, a large city there, a railroad on this line, etc.
>
> The discussion was a hot one. After an hour, and much pleading, permission was given to consult the rolled up wall map. I will never forget one young student, as he pointed his finger at the foot of Lake Michigan, shouting, "Yipie, Chicago is at the end of the pointing-down lake." And another replying, "Well, OK: but Chicago's no good for the rivers and it should be here where there is a big city (St. Louis)." These children were thinking, and learning was an instrument for

checking and improving the process. To at least a half dozen children in the class it is not a matter of indifference that no big city is to be found at the junction of Lake Huron, Lake Michigan, and Lake Ontario. They were slightly shaken up transportation theorists when the facts were in.*

The context of this inquiry was the geography of the North Central States. The children were reacting to the data (f) of the blank maps with hypotheses (d) about the relationships between cities, rivers, and so forth. They got these hypotheses by combining their concepts (c) to yield implicit generalizations that seemed to be appropriate for this occasion. (This is a crucial point. We do not ordinarily carry finished sentences in our heads but rather, we construct them as they are needed. Although it is often claimed that we "remember" generalizations better than facts, this is not quite accurate. The rolling stock of our thinking is more likely to be a network of concepts, together with a carefully nurtured capacity for converting these into generalizations as the occasion demands.) The children tested their hypotheses by making predictions (e) about where cities etc. were to be found in the North Central States. When the wall map was consulted, i.e., when "the facts were in" (f), the children confirmed or rejected their predictions and hypotheses according to principles which they had developed for deciding in what ways a proposition was to be considered true (a). Finally, there was an assumption (b) that "transportation theory" was a legitimate way of approaching the context, instead of, say, historical accidents or some other approach. Of course, the inquiry need not stop here. The children probably went on to consider other hypotheses that might help to account for the predictions that went wrong (or right), and thus the process continues.

There are several general points that we ought to make about this. (1) All six levels are implicitly involved in social studies thinking at any time, although our thoughts may be focused explicitly on one or more levels at a given moment. (2) The emphasis of our thinking moves between the various levels, so that at one time a person might be concentrating explicitly on "the facts," at another time on various hypotheses, etc. There is no set order of proceeding from one level to the next. Sometimes we move from a more theoretical to a more factual emphasis, at other times we move in the opposite direction. (3) It is not necessary for one to label his thinking at each level as it occurs, i.e., to call every prediction "a prediction," every generalization "a generalization," and so forth. Intuitive thinking is often more fruitful, and more enjoyable, at certin stages of inquiry; furthermore, we do not yet know how early in his development a child can actually be aware of different levels in his thinking. On the other hand, one should eventually develop a capacity for specifying the process of his thought, in order to gain greater control over it.

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* Jerome S. Bruner, Learning and Thinking. Harvard Educational Review. Vol. 29, #3, Summer 1959, pp. 134-192.

Objective 5. Analyze and assess provisions for enquiry in written descriptions of curricula, using an enquiry checklist.

An important competency needed by school leaders who are responsible for curriculum improvement is that of analyzing and assessing different curricula in terms of how, and to what degree, they are designed to teach enquiry.

In examining a curriculum for features involving teaching students enquiry, you should seek answers to the following questions that are included in the checklist used in this unit to assess curricula in terms of enquiry.

1. What emphasis does the curriculum place on teaching students ideas rather than facts?

   An enquirer deals mainly with ideas. Facts are important only as evidence related to ideas (principles, conclusions, comparisons, interpretations, etc.).

2. What emphasis does the curriculum place on teaching students the methods of enquiry used by scholars or scientists in the subject area?

   An important way to gain an understanding of a subject is to learn how new knowledge of that subject is gained by specialists in studying it.

3. What emphasis does the curriculum place on teaching students to make hypotheses about phenomena?

   A critical step in problem solving is that of selecting or creating one or more hypotheses (or approaches) that could provide a solution.

4. What emphasis does the curriculum place on teaching students to test their hypotheses (or plans)?

   Once hypotheses have been stated, or plans made, the next step in problem solving is that of tryout through examining evidence, through conducting investigation, or through implementing a plan of action.

5. What emphasis does the curriculum place on students' discovery of principles or rules?

   One important feature of "discovery" teaching is having students seek the principle or rule applying to a set of data (as in the case of the math sequence beginning 2 - 5 - 14).

6. What emphasis does the curriculum place on having students conduct individual or group enquiry (problem-solving) projects?

   The project method obviously is a key approach to teaching enquiry.

Ideally, you would have the full curriculum in front of you when you examine it for enquiry. Since this is not practical as you study this unit, you are given brief descriptions of curricula to offer you practice in analyzing curricula in terms of their provisions for enquiry.

Exercise 4 presents you with descriptions of two curricula in elementary social studies. These curricula have been selected to offer a sharp contrast between the "traditional" approach to teaching social studies and the newer approach emphasizing enquiry. You will have no trouble identifying which is which. Since the relatively traditional curriculum is 15 years old and doubtless has been removed from its publisher's inventory, its name has been disguised and its publisher is not mentioned.

Your task in Exercise 4 is to study the two descriptions and to fill out the Worksheet for each. Exercise 4A and its Worksheet are for The States of Our Union textbook. Exercise 4B is for the Social Science Laboratory Units. In assessing a curriculum for enquiry, do not expect it to emphasize all six of the features of enquiry instruction listed on the preceding page.

When you complete the two parts of Exercise 4, you will find the Answer Keys immediately following the materials for that exercise.

After you check your work on Exercise 4, you should continue by doing Exercise 5 that calls upon you to examine one of the three additional curricula for which descriptions are presented following the Answer Keys to Exercise 4. In Exercise 5, you choose that one of the three curricula you prefer, fill in its name at the top of the Exercise 5 - Worksheet, and complete the Worksheet following study of the description of the curriculum you chose. The three curricula are in elementary science, secondary science, and elementary math. Answer Keys for each of the three curricula follow the descriptions.

Exercise 4A Curriculum Description:

THE STATES OF OUR UNION

The States in Our Union is a social studies textbook and Teacher's Guide for use in the middle grades of the elementary school.

Aims

1. To help middle-graders learn first about the state most important to them - their own; about the region in which it is located; and about other regions of the nation.
2. To help students get acquainted with the rights and responsibilities of citizens in their state.
3. To help youngsters grow into good citizens.

Contents

The textbook is divided into the following major sections: In Your State; In the Northeast; In the North Central States; In the South; In the West; In Alaska and Hawaii. The first unit contains material on learning to read and use maps. There is material on the use of reference skills through "Learning to Find and Use Interesting Facts." Each of the sections focuses on one or more basic human activities such as comparing and contrasting people and their activities in different places, making judgments and drawing conclusions about providing recreation, transportation, purposes of education, and conservation in the state. Other topics developed are organizing and governing, creating new tools and techniques through education and industry, and producing and consuming goods and services.

Goals and Teaching Strategies

The authors of the text stress the following goals that form common threads in many of the units:

1. Knowing and observing rules
2. Using knowledge of the past to understand the present better and to anticipate the future better

3. Appreciating the contributions of others

4. Showing respect for the flag and appreciating one's heritage from the past

5. Accepting the democratic ideals and accepting the responsibility for perpetuating them

The teaching strategy for this textbook-based course is exposition by the teacher coupled with reading of the text. Exercises at the end of each chapter require the student to learn factual information rather than concepts. Questions in the exercises demand a recall of facts and definitions of new terms introduced in the chapter. Some exercises are in the form of matching beginnings and endings of sentences. The Teacher's Guide provides other kinds of activities in the form of "projects" such as keeping a scrapbook, reading biographical and other reference material related to units, and mapping.

An example will show how topics are presented. The book devotes eight pages to a unit, "Southern Cities." The text presents each city in a descriptive manner:

> Baltimore, which is almost as old as New Orleans, was started by a group of tobacco planters. Each of these planters had been shipping his tobacco from his own dock.

The narrative explains that shipping from a central point would be easier, so a community was set up at the mouth of one of the rivers that flow into Chesapeake Bay. The text then devotes four paragraphs to the setting of Baltimore. Two of these paragraphs describe pictures illustrating the text. The text is highlighted in bold type by "Find Baltimore on your map. Why do you think settlers established a town in this location?" At first this question appears to be enquiry-oriented; but in fact the student already has been given the answer in the text.

The student exercises at the end of the chapter are titled "Organizing and Using What You Have Learned." One section of these exercises is "Using a Waterways Map" in which the student answers such questions as: "1. Name five ocean ports. 2. Name five river ports...." Another exercise, "Describing Which is Which," calls for an explanation of meanings of 12 vocabulary terms introduced in the chapter. The student is then to determine, "Which give a picture of the Old South? Which give a picture of the South today?" Still another section, "Matching Beginnings and Endings" provides the following instructions to the student, "Read the groups of words listed below. Then match each beginning with the right ending." There are eleven sentences in this exercise.

The Teacher's Guide section of the book instructs the teacher to call attention to the picture of the clipper ship as a form of motivation to introduce the chapter. It continues with: "Then say to the students, 'Do you think this was a river boat or an ocean-going vessel? Read to find out more about why this seaport (Baltimore) grew into a large city and why it is important today.' "

YOU WILL FIND THE EXERCISE 4A - WORKSHEET ON THE NEXT PAGE

EXERCISE 4A - WORKSHEET

Assessing a Curriculum Description for Enquiry

Directions: After studying the description of the curriculum involved, fill in your ratings below and write down your reasons for making them. Check your answers against those offered in the Answer Key for Exercise 4A.

CURRICULUM AREA: Social Studies GRADE LEVEL: Middle Elementary

NAME OF CURRICULUM: The States of the Union

1. Emphasis on teaching ideas rather than facts? H___ M___ L___ None___ ?___
   Basis for your rating:

2. Emphasis on teaching methods of enquiry used by scientists or scholars in the subject area? H___ M___ L___ None___ ?___
   Basis for your rating:

3. Emphasis on students making hypotheses? H___ M___ L___ None___ ?___
   Basis for your rating:

4. Emphasis on students testing hypotheses by examining evidence or investigating? H___ M___ L___ None___ ?___
   Basis for your rating:

5. Emphasis on student discovery of principles or rules? H___ M___ L___ None___ ?___
   Basis for your rating:

6. Emphasis on students conducting individual or group enquiry (problem-solving) projects? H___ M___ L___ None___ ?___
   Basis for your rating:

EXERCISE 4A - ANSWER KEY

Assessing a Curriculum Description for Enquiry

Explanation: The answers given below are not meant to be the only correct ones, since they reflect the judgments of the author of this unit. They should be helpful to you in checking your answers.

CURRICULUM AREA: Social Studies GRADE LEVEL: Middle Elementary

NAME OF CURRICULUM: The States of the Union

1. Emphasis on teaching ideas rather than facts? H___ M___ L✓ None___ ?___
   Basis for your rating:

   Stress is placed on learning factual information.

2. Emphasis on teaching methods of enquiry used by scientists or scholars in the subject area? H___ M___ L___ None✓ ?___
   Basis for your rating:

   No mention of this aim.

3. Emphasis on students making hypotheses? H___ M___ L___ None✓ ?___
   Basis for your rating:

   No mention of this aim.

4. Emphasis on students testing hypotheses by examining evidence or investigating? H___ M___ L___ None✓ ?___
   Basis for your rating:

   This aim is not mentioned.

5. Emphasis on student discovery of principles or rules? H___ M___ L___ None✓ ?___
   Basis for your rating:

   Principles, such as related to the location of cities, are told the student.

6. Emphasis on students conducting individual or group enquiry (problem-solving) projects? H___ M___ L✓ None___ ?___
   Basis for your rating:

   Projects mentioned are not true enquiry activities; e.g., keeping a scrapbook, mapping.

Exercise 4B Curriculum Description:

SOCIAL SCIENCE LABORATORY UNITS

The Social Science Laboratory Units, a program for Grades 4, 5, and 6, were developed by Ronald Lippitt, Robert Fox, and Lucille Schaible of the University of Michigan as a cooperative research project with Science Research Associates (SRA) in Chicago.

PURPOSES: The two main aims of this program are:

1.. to help students develop the intellectual tools associated with the role of a social scientist in his investigation into the causes and effects of human behavior

2. to develop skills of value inquiry, allowing the students to understand why they hold their values and why others hold different values

The implication recurs throughout the materials that students can develop a positive attitude toward inquiry as a method for recognizing and solving human behavior problems. There is a great deal of emphasis throughout these units on the necessity of learning how to receive and respond to information about behavior of people.

CONTENT: The curriculum consists of seven units, as follows: Learning to Use Social Science, Discovering Differences, Friendly and Unfriendly Behavior, Being and Becoming, Individuals and Groups, Deciding and Doing, and Influencing Each Other. The content is drawn from social psychology. The classroom is the laboratory. Pupils observe samples of human behavior - a friendly act, a misunderstanding, perhaps a fight. They search for reasons why. They discuss their feelings. They explore their values. Children take turns playing different roles as one way of learning about others' feelings.

The first unit, Learning to Use Social Science, sets the stage for the later units. This unit is a prerequisite because it presents the

methodology. Here children become acquainted with the social scientist, his work, and his methods. What does the social scientist study? The behavior or people. How? By observing people and asking them questions. Because he is a scientist, he constantly strives to be objective about what he has observed. He tries to establish the causes and effects of certain behavioral interactions. He conducts experiments to test his theories. He makes predictions based on the information he has collected. Pupils will follow much the same procedures in their investigations. They will learn how to approach the study of behavior as scientists would.

Instruments for data collection are provided in Project Books. Pupils use interviews, questionnaires, and observation guides to gather information. Later, they tabulate and analyze the data collected. What did they discover? They attempt to make generalizations. Thus they might discover that frustration leads to aggression, that is, when a person is constantly blocked he tends to act in unfriendly ways.

GOALS AND TEACHING STRATEGIES: The elementary school child is introduced to the social sciences:

1. to give him some understanding of behavior that has been discovered through the use of social science methods
2. to help him relate these understandings to the world in which he lives
3. to learn the scientific methodology of studying human phenomena as applied to human interaction
4. to translate and interpret raw data from observation
5. to extrapolate knowledge gained from one situation toward application in other situations at an elementary level

A large part of the program is geared to study of differences in cultural, age, ethnic, and sexual factors as being causal in differing behavior. The knowledge about human behavior is structured only after students have engaged in numerous observations within their classrooms. Even then, the structure is quite loose. Very little exposition is used. Many class and group discussions are proposed in the course. Question-asking is done by teacher and by students. Role-playing and group discussions are the chief types of student-student interaction.

In the classroom, pupils are first given a sample of behavior to observe. The sample could be an episode on a record; a skit that is role-played in class; a story to read in the Resource Book. The behavior specimen could be a friendly act, a fight, or a conflict of some kind. All are designed to trigger their curiosity.

The teacher initiates a discussion about the behavior by asking, "What actually happened? Why do you think so?" She urges children to describe the event and make inferences about the causes. "Will it happen again that way? Why?" The teacher asks children to make a value judgment about the behavior, "Was it a good thing for those people to behave that way? How would you change the story to make the ending different?"

With the teacher's help children learn to phrase their questions into those that can be answered by scientific investigation. For example the question, "How come Bud always acts so mean?" eventually becomes the broad inquiry, "What causes unfriendly behavior?" Now, data can be collected.

EXERCISE 4B - WORKSHEET

Assessing a Curriculum Description for Enquiry

Directions: After studying the description of the curriculum involved, fill in your ratings below and write down your reasons for making them. Check your answers against those offered in the Answer Key for Exercise 4B.

CURRICULUM AREA: Social Studies GRADE LEVEL: Grades 4-6

NAME OF CURRICULUM: Social Science Laboratory Units

1. Emphasis on teaching ideas rather than facts? H___ M___ L___ None___ ?___
   Basis for your rating:

2. Emphasis on teaching methods of enquiry used by scientists or scholars in the subject area? H___ M___ L___ None___ ?___
   Basis for your rating:

3. Emphasis on students making hypotheses? H___ M___ L___ None___ ?___
   Basis for your rating:

4. Emphasis on students testing hypotheses by examining evidence or investigating? H___ M___ L___ None___ ?___
   Basis for your rating:

5. Emphasis on student discovery of principles or rules? H___ M___ L___ None___ ?___
   Basis for your rating:

6. Emphasis on students conducting individual or group enquiry (problem-solving) projects? H___ M___ L___ None___ ?___
   Basis for your rating:

EXERCISE 4B - ANSWER KEY

Assessing a Curriculum Description for Enquiry

Explanation: The answers given below are not meant to be the only correct ones, since they reflect the judgments of the author of this unit. They should be helpful to you in checking your answers.

CURRICULUM AREA: Social Studies GRADE LEVEL: Middle Elementary

NAME OF CURRICULUM: Social Science Laboratory Units

1. Emphasis on teaching ideas rather than facts? H ✓ M___ L___ None___ ?___
   Basis for your rating:

   There is strong emphasis on testing ideas rather than learning facts.

2. Emphasis on teaching methods of enquiry used by scientists or scholars in the subject area? H ✓ M___ L___ None___ ?___
   Basis for your rating:

   This is the topic of the first unit.

3. Emphasis on students making hypotheses? H ✓ M___ L___ None___ ?___
   Basis for your rating:

   Students search for reasons to explain observations.

4. Emphasis on students testing hypotheses by examining evidence or investigating? H ✓ M___ L___ None___ ?___
   Basis for your rating:

   Students gather data to test hypotheses.

5. Emphasis on student discovery of principles or rules? H ✓ M___ L___ None___ ?___
   Basis for your rating:

   Students make generalizations such as frustration leads to agression.

6. Emphasis on students conducting individual or group enquiry (problem-solving) projects? H___ M ✓ L___ None___ ?___
   Basis for your rating:

   Students use project guides to conduct investigations.

Exercise 5 Curriculum Description:

SCIENCE--A PROCESS APPROACH

Science--A Process Approach is a sequential elementary science curriculum K-6 (grades 7,8 in development) developed by the American Association for the Advancement of Science (AAAS) and based on learning theory as presented by Robert Gagné. The Project Director was John R. Mayor of the AAAS staff.

PURPOSE: The aim of the Commission in creating the program was to develop a comprehensive elementary sequence, including experimental laboratory exercises, that focused primarily on ways of developing basic skills in the processes of science. In addition, it was to be designed to make possible particular achievements in the processes of science which could be related to individual development in the knowledge of science and its methodology. Another major purpose is to teach facts in relation to the procedures of scientific inquiry through basic skills such as observing, measuring, predicting, defining operationally, inferring, classifying, etc.

CONTENT: The actual content is secondary in importance to the following processes emphasized in this curriculum:

Observing: Identifying objects and object properties, changes in physical systems, controlled observations, ordering a series of observations.

Classifying: Classifications of physical and biological systems, multi-stage classifications, coding, tabulation.

Using Numbers: Identifying sets and their members, ordering, counting, adding, multiplying, dividing, finding averages, using decimals, and powers of ten.

Measuring: Identification and ordering of lengths, demonstration of rules for measurement of length, area, volume, weight, temperature, force, and speed.

Using Space/Time Relationships: Identification of shapes, movement and direction, rules for straight and curved paths, changes in position, and finding of linear and angular speeds.

Communicating: Bar graph descriptions of simple events, describing physical objects and systems, construction of graphs and diagrams for observed results of tests.

Predicting: Interpolation and extrapolation in graphic data, formation of ways of testing procedures.

Inferring: Inferencing for observations of physical and biological phenomena, construction of situations to test inferences drawn from hypotheses.

Defining Operationally: Distinguishing between operational and non-operational definitions, constructing operational definitions in new problems.

Formulating Hypotheses: Distinguishing hypotheses from inferences, observations, and predictions; constructing and testing hypotheses.

Interpreting Data: Describing graphic data and inferences based upon them, constructing equations to represent data, relating data to hypotheses, generalizing from experimental findings.

Controlling Variables: Identifying manipulated and responding (independent and dependent) variables in a demonstration of an experiment, conducting an experiment, identifying the variables and describing how variables are controlled.

Experimenting: Reiterating the sequence for controlling variables, interpreting accounts of scientific experiments, stating problems, constructing hypotheses, and carrying out experimental procedures.

GOALS AND TEACHING STRATEGIES: The process skills (described in "CONTENT" of this abstract) form the core of Science--A Process Approach and through them the child becomes highly involved in using the processes of science in becoming an active investigator. The use of laboratory techniques--especially the experiment deserves special attention. The experiment is the sharpest tool of science and in devising an experiment the child exercises his ability to pose a question, to consider possible answers, to select appropriate instruments, to make measurements, and to be aware of the sources of error. No textbook is provided with this program. Most

of the reading materials are provided for the teacher to direct inquiry-oriented sessions with the students. Rather than reading about science, in this curriculum children learn about science through the use of their senses, mental involvement, and direct manipulation of things in their immediate environment.

The assumption of Science--A Process Approach is that science is much more than a collection of facts, and that children will benefit from experience that will enable them to acquire the use of certain processes that are essential for the learning of science. A basic belief is that the scientific approach to gaining knowledge of man's world has a fundamental importance in the general education of every child.

Exercise 5 Curriculum Description:

BIOLOGICAL SCIENCES CURRICULUM STUDY

(National Science Foundation. Course and Curriculum Improvement Projects. Washington, D.C.: U.S. Government Printing Office, 1970. P.17.)

BIOLOGICAL SCIENCES CURRICULUM STUDY (BSCS). William V. Mayer, University of Colorado, P.O. Box 930, Boulder, Colo. 80302. (Grantee: American Institute of Biological Sciences, 3900 Wisconsin Ave., N.W., Washington, D.C. 20016 (1959-1962); University of Colorado, Boulder, Colo. 80302.) (1962-1969)

The BSCS was established for the improvement of biological education at all levels. Its initial concentration has been on programs for secondary school biology, including texts, laboratory materials, programmed materials, research problems, films and slides for students of diverse abilities from below average to gifted in grades 10-12, as well as materials for teachers and administrators. The stress is placed upon teaching major principles of biology in depth with special emphasis on investigative laboratory work and the teaching of science as inquiry. BSCS policy is determined by an elected Steering Committee of biologists, educators and administrators, meeting annually or semi-annually, and an Executive Committee meeting as required. The content for each major program is reviewed by a special committee of persons well qualified in the particular field.

Three versions of a modern high school course in biology are now available for use in the tenth grade. Although approximately 70 percent of the content is common to all three versions, each one approaches the study of biology from a distinctive point of view. *Biological Science: Molecules to Man* (Blue Version) uses a molecular-biochemical-evolutionary approach; *High School Biology: BSCS Green Version*, an ecological-evolutionary approach; *Biological Science: An Inquiry Into Life* (Yellow Version), a cellular-biochemical-evolutionary approach. These three courses are equivalent in depth of content and designed for students of average and above-average ability. Each version includes a text, laboratory materials, teachers' manual, quarterly tests and a comprehensive final examination.

BSCS laboratory blocks provide six-week programs of concentrated investigation suitable for regular classes, and cover a wide range of areas, including development, ecology, behavior, genetics, and metabolism. A book describing many items of home-made, relatively inexpensive equipment and simplified laboratory techniques has also been produced.

A special handbook for teachers discusses the aims, philosophy, and methods of the BSCS and also presents a set of *Invitations to Enquiry*, prepared discussions on selected biological problems designed to bring out aspects of scientific methods and philosophy.

For academically unsuccessful students the BSCS has prepared a set of materials under the title of *Biological Science: Patterns and Processes*. These materials have been successful with students who have difficulties with regular classroom materials. This program includes a sequence of varied student materials and a comprehensive teacher's edition.

For very capable students the BSCS has published a series of four volumes containing a total of 160 selected investigations they might wish to undertake.

The Biological Sciences Curriculum Study has also prepared a second course in biology emphasizing experimentation and the processes of science. This volume is a non-repetitive work, depending on the student's prior knowledge of biology but not recapitulating it. It consists of a text and a detailed teacher's edition.

Other aids for students include a series of programmed materials on such topics as population genetics, DNA, human reproduction, and energy relationships, a series of pamphlets on special topics in biology, a sequence of inquiry slides that can be projected in daylight upon a blackboard and the image marked upon by student and teacher in carrying through the inquiry, and a series of 40 *Single Topic Inquiry Films*, which serve as data sources for investigating a specific biological problem.

For information purposes the BSCS produces a *Newsletter* available free upon request, a Bulletin Series concerned with special aspects of biological education, a Special Publication Series dealing with teacher preparation, teacher training films and an information film circulated upon request to those interested in the programs of the BSCS.

For a current listing of BSCS materials and their sources write directly to the project director. *BSCS International News Notes* provides information on BSCS materials that have been translated into languages other than English.

Further information is available from the project director.

about BSCS biology

What is the background of the BSCS materials? Who prepared them? Under what sponsorship was the work undertaken?

In 1958, the BSCS was organized by the Education Committee of the American Institute of Biological Sciences (AIBS) with a membership of more than 85,000 biologists. The BSCS function was "to seek the improvement of biology education." Initial major support for the BSCS has come from National Science Foundation grants. Other grants such as those from the Ford Foundation, USOE, Rockefeller Foundation, and the Asia Foundation have assisted BSCS activities. Fiscal responsibility for the BSCS was assumed by the University of Colorado in 1963, and in 1967 the University assumed both general administrative and fiscal sponsorship of BSCS by establishing the Biological Sciences Curriculum Study Center at the University of Colorado.

General policy for the BSCS is established by a 20-member Steering Committee, which includes both professional biologists and educators at the college and secondary level. The Chairman of the Executive and Steering Committees is Dr. Arnold B. Grobman, Dean of Rutgers College, Rutgers University. The Director is Dr. William V. Mayer, University of Colorado, Boulder.

The BSCS originally developed three parallel sets of course materials for high school biology: *Biological Science: Molecules to Man* (Blue Version), *High School Biology, BSCS Green Version*, and *Biological Science: An Inquiry Into Life* (Yellow Version). These were prepared by teams of writers working at Summer Writing Conferences during three successive years—1960, 1961, and 1962. Each version consists of text, laboratory materials, and appropriate teacher's manuals. In the years following each of the first two summers' work, the materials were widely tested and reviewed to give feedback for the succeeding rewriting. Writing teams were made up of research biologists and high school biology teachers.

In addition to the initial three versions of the high school biology text, the BSCS subsequently produced *Biological Science: Patterns and Processes*, a 10th-grade book for the academically unsuccessful; *Biological Science: Interaction of Experiments and Ideas*, a non-repetitive second course; a set of six-week Laboratory Blocks dealing with specific topics in biology; a programmed sequence of filmed inquiries as Single Topic Films; a four-volume set of *Research Problems in Biology* for the superior student; and a series of Pamphlets on biological topics.

For the teacher BSCS has developed the *Biology Teachers' Handbook*; a series of Bulletins on biological education; Special Publications dealing with implementation of the BSCS program; the BSCS NEWSLETTER, an informational publication sent free on request to those interested in BSCS materials; Achievement Tests for each of the versions, *Biological Science: Interaction of Experiments and Ideas*, and *Biological Science: Patterns and Processes*, as well as a Processes of Science Test (POST) that can be used as a pre- and post-test, and Comprehensive Finals for each of the three versions of 10th-grade biology. The BSCS materials constitute a flexible program from which the teacher may select that portion which best suits his ability and interest in achieving his goals. The availability of these projects of the BSCS is delineated at the end of this publication. Other materials currently in the development stage will be announced in the NEWSLETTER as they are ready for use.

What are the aims and objectives of the BSCS program?

The original charge to the BSCS was the improvement of biological education at all levels. As it was impossible to implement such a broad charge effectively, the initial decision was to provide teachers with materials that properly reflect both the content and methodology of biology as a 20th century science and to concentrate this effort at the point in American education where the bulk of students are involved in the course in biology, chiefly the tenth grade of secondary school. To do this, the BSCS found it necessary to prepare introductory high school biology courses, suitable for wide use in the *average* high school, with *average* classes, to give students a basic understanding of science and of scientific processes; and in so doing, to build scientific literacy to aid in the preparation of the student for responsible adult citizenship. The primary objective is to teach science as a way of thinking—as a method of seeking answers. To accomplish this, underlying concepts and understandings are stressed. Student work is centered in the laboratory, where real problems are explored. Open-ended experiments and other materials are used as media for conveying an understanding of science. Through emphasis on basic concepts and the illustration of such concepts in varied ways, the student is given practice in analyzing data, drawing conclusions, seeking relationships from generalizations, and in finding his own answers.

How do BSCS Biology materials differ from other materials available for this grade level? What is the justification for such differences?

BSCS Biology differs from conventional treatments in several ways:

First, all three versions have significant unifying threads. This unity arises from the agreement *of those concerned* with BSCS Biology that nine basic emphases should be woven in and through each of the three versions. These are:

Change of living things through time—evolution
Diversity of type and unity of pattern of living things
Genetic continuity of life
Complementarity of structure and function
Biological roots of behavior
Complementarity of organisms and environment
Regulation and homeostasis: the maintenance of life in the face of change
Science as inquiry
Intellectual history of biological concepts

Second, it is a general high school program that has resulted from a genuine cooperative approach among teams of research biologists, high school biology teachers, science educators, and other contributing specialists. It represents not a revision of old thinking in high school biology, but rather a completely new start based on the most up-to-date information in the field of biology. For example, where traditional texts primarily emphasized classical systematics and morphology, the organ and tissue level in biology, vocabulary, and rote memorization of isolated facts, the BSCS versions place greater emphasis on other levels of biological organization, attempt a balance in subject matter, de-emphasize vocabulary as such, emphasize the scientific process and the concepts and principles of biological science.

Third, BSCS Biology puts a greater stress on experimental laboratory work than did traditional texts. Teachers using BSCS materials report spending more than double the time of the class in the laboratory than they had done previously with traditional materials. Furthermore, the traditional illustrative type of laboratory exercise is de-emphasized and stress is given to investigative exercises which introduce the student to the inquiring processes of science.

Fourth, biology is used as a vehicle whereby students become acquainted with both science and scientific processes. By extensive, but not exclusive use of inquiry, students are encouraged to observe, hypothesize, experiment, gather data, analyze and draw conclusions. This approach encourages the student to synthesize previously apparently unrelated facts and to develop generalizations through independent study and thought.

It is the considered opinion of the producers of BSCS materials that unifying threads or themes as the structure for the high school biology course, as well as the different emphasis in terms of biological levels, more adequately reflect modern biology than did former approaches, even though excellent teachers in isolated situations had been teaching along these lines with considerable success for years, despite lack of proper classroom materials.

The inquiry emphasis encourages critical attitudes and the employment of logical processes in the solution of problems. It places more of the learning responsibility upon the student and frees the teacher to work with students rather than lecturing to them.

The central position of the laboratory reflects the conviction that a student comes to understand science through participating in science, rather than by serving as a bystander who only reads about science, watches demonstrations, or routinely follows patterned expository work outlines.

Has BSCS High School Biology resulted in a national curriculum?

No. The BSCS materials are available to schools along with the more than two dozen other high school biology books. Individual schools and school systems are free to select from among the competing texts which include the BSCS Biology books. The aim of the BSCS is not to "sell" books, but to provide models—to educators, publishers, textbook writers—of what competent research biologists, high school biology teachers, psychologists, and other specialists think are good ways of teaching general biology at the high school level. Other writers have prepared their own materials after reviewing the BSCS books and the entire area has been accordingly enriched.

By introducing additional materials, BSCS has had the effect of reducing the possibilities of a national curriculum by lessening teacher dependence upon the two books which were used in the majority of high schools in the United States prior to 1960.

What is the difference between the three BSCS versions?

Biology as a field of knowledge can be thought of as a three-dimensional structure:

The levels of biological organization constitute one dimension.
The organizing conceptual schemes (BSCS themes) constitute a second dimension.
Kinds of organisms used for illustrative purposes constitute a third dimension.

Biological inquiry, as a method of obtaining knowledge, pervades the whole structure. When biology is conceived of in this way, specific facts and principles become meaningful as they are related to these dimensions. Without so relating them, specific facts and principles represent isolated clusters or bits of information; by so relating them, these bits become a part of an organized intellectual structure.

This does not mean that there is only one way of understanding biology as a field of knowledge; on the contrary, biology at the present time allows for a variety of views as to how its parts are interrelated. For example some biologists think of molecular biology as the fundamental area of biology upon which all other biological knowledge is based —that biochemistry is fundamental to an understanding of the evolution of living organisms. Others consider that reproduction, development, and evolution are the areas which deserve the major emphasis. Still other biologists consider the ecological and behavioral aspects of primary importance and feel that problems relating to the human species in the biosphere are the most appropriate for study by future citizens. These three, of the many possible ways of studying biology, are the basic approaches in *Biological Science: Molecules to Man* (Blue Version), *Biological Science: An Inquiry Into Life* (Yellow Version), and *High School Biology, BSCS Green Version*, respectively.

These, then, are three particular interpretations of the relationships among the parts of biology. The three-dimen-

sional structure presented above provides a general framework within which this variety of specific views is possible. It does not prejudice one or another particular view; rather it provides a framework within which this variety of particular views can better be understood.

The three approaches used in the versions of BSCS Biology are all valid. There is no indication that any one version is more suited to a rural or an urban setting, to a more or less sophisticated student body, nor to a more or less well-prepared teacher. The choice among the versions is best made by the teacher, based on his own background and interests, and on the assessment of the students' background and interest in the particular milieu in which they work.

What other BSCS materials are available for use? What supplemental materials are available for the student?

Student materials for each version include both text and laboratory experiments. These may be bound together or separately. The books are available only in sets including both lab and text, since both volumes are required for an integrated and balanced presentation of BSCS Biology.

A second course in high school biology entitled *Biological Science: Interaction of Experiments and Ideas* has been prepared.

Special material designed for the academically unsuccessful student is available as *Biological Science: Patterns and Processes.*

There is a series of six-week Laboratory Block units available. Any one of these blocks may be used to supplement any of the courses of BSCS Biology. Each block is centered around one area of biology, and through the laboratory experiences therein, the student can gain a deep insight into the processes of scientific inquiry.

Other supplemental materials for use by students include: The BSCS Pamphlet Series of twenty-four pamphlets, with others projected; and four volumes of *Research Problems in Biology*, a series of research prospectuses which may be used by the individual superior student as an out-of-class, long-range research activity.

A series of 40 Single Topic Inquiry Films is available and may be used in connection with BSCS Biology. This series consists of short, silent films that provide data for developing specific concepts found in BSCS Biology. The films are designed as inquiries into biological problems, with Teacher's Guides for directing the inquiry.

A new visual device for developing inquiry skills has been developed with Guidance Associates. It consists of a sequence of slides designed for daylight blackboard projection that involve students in the inquiry process by presenting selected observations and data which the student is required to interpret before proceeding further.

The wide array of BSCS instructional materials available for student use allows the teacher maximal flexibility of curriculum design to provide for almost every interest and ability group and to use to best advantage the specific teaching situation in which pupils and teacher operate.

What materials are available for the evaluation of students in BSCS programs?

Quarterly tests are available for each version, as well as an end-of-year test. For the 1968 editions, these are available from the publishers concerned. A Processes of Science Test (POST) is usable as both a pre- and post-test for all BSCS programs. In addition, achievement tests are available for the BSCS Second Course—*Biological Science: Interaction of Experiments and Ideas* and for the program for the academically unsuccessful student—*Biological Science: Patterns and Processes*. A book of test items is available for the laboratory blocks—*Tests and Teacher's Resource Book*. These tests were prepared by the BSCS with the technical assistance of a professional testing agency.

In 1966, the BSCS prepared a sequence of experimental test items published in booklet form for each of the three versions. The approximately 800 questions in each booklet were keyed to specific version chapters of the 1963 editions and were to be used by teachers where appropriate. The booklets were not tests as such but simply collections of items from which tests could be produced. The questions were primarily concerned with inquiry skills because research had shown that these were types of questions teachers had greatest difficulty in constructing. These booklets were widely distributed free of charge to BSCS teachers but have not been reprinted and are no longer available. Future plans for similar booklets are being considered and their availability will be announced in a future NEWSLETTER.

What supplemental materials are available for the teachers? Are there suggestions for the teacher so that he can use BSCS materials to maximum advantage?

Each BSCS program includes appropriate and specific Teacher's Manuals. For publications, the manuals include teaching strategies, techniques, additional activities, optional films and references, and specific commentaries regarding each of the laboratory exercises noting possible problems and pitfalls. For the Single Topic Inquiry Films and the Inquiry Slides, detailed Teacher's Manuals are supplied delineating each of the visuals, models of student reaction, and a complete teaching strategy. In addition to these detailed teaching aids for specific programs, the BSCS has produced the *Biology Teachers' Handbook* that provides a more general orientation for the biology teacher. It not only includes selected Invitations to Enquiry, but also background information on such topics as statistics, physics and chemistry, as well as suggestions for evaluation, bibliographies, film lists, supply sources, such techniques as the care of living animals, and teaching tips and techniques. In addition, the *Biology Teachers' Handbook* provides background information concerning the philosophy and history of the BSCS. Model teaching schedules have been prepared for teachers who desire them. Bulletins and Special Publications provide the teacher with additional information relative to biological education. The BSCS NEWSLETTER, an informational publication about BSCS Biology, appears periodically and is sent to individual teachers free upon request to BSCS. It provides general information about the Biological Sciences Curriculum Study and specific items such as equipment and supply lists relative to the BSCS programs.

Exercise 5 Curriculum Description:

Greater Cleveland Mathematics Program

INTRODUCTORY STATEMENT

PREPARED BY THE GREATER CLEVELAND MATHEMATICS PROGRAM
RESEARCH STAFF

Genesis and Purpose

The Educational Research Council of Greater Cleveland was created in 1959 by Dr. George H. Baird, the Council's Executive Director, as an answer to a recognized need for a dynamic and continuous effort to improve the quality of elementary and secondary education.

The Council is an independent, non-profit organization. Its permanent staff of subject matter and educational specialists devotes full time to educational research and implementation. With the help of local educators and nationally recognized authorities in such fields as mathematics, social science, and testing, the Council is working to develop modern school curricula which will enable all students to meet the ever-changing present-day needs and the ever-increasing undefinable needs of the future.

Responding to the concerted request of 21 superintendents from participating school districts in the Greater Cleveland area, the Curriculum Research Department of the Council undertook as its first project a research and implementation study in mathematics education. The purpose of the project was set forth: ". . . to develop a comprehensive, sequential mathematics program for *all* children in grades kindergarten through twelve, a program which is both mathematically correct and pedagogically sound." Surveys were made of existing arithmetic and mathematics programs and materials, of the best learning theories, and of the needs of the children and professional staffs of the Council schools. The Greater Cleveland Mathematics Program (GCMP) with its preparation of materials, teacher training, and evaluation design was the direct outgrowth of this initial investigation. The materials in this program were revised for use in 1962-63.

GCMP's Educational Philosophy

The Greater Cleveland Mathematcs Program is a concept-oriented modern mathematics program in which the primary emphasis has been placed upon thinking, reasoning, and understanding, rather than on purely mechanical responses to standard situations. The child is continuously encouraged to investigate how and why things happen in mathematics. He is led to make generalizations, to test these generalizations, and to find new applications for them.

Only a few years ago many of the mathematical concepts included in the GCMP were thought to be too difficult for children in the primary grades. Experience with more than 125,000 children, however, has shown that children are able not only to understand these concepts, but that each new step in the learning process takes on more meaning because of this understanding.

In developing GCMP, the recommendations of several nationally recognized groups were taken into consideration. These groups include the National Council of Teachers of Mathematics, the Mathematical Association of America, and the Commission on Mathematics of the College Entrance Examination Board. The recommendations of noted mathematicians, such as Dr. John G. Kemeny, chairman of the Department of Mathematics, Dartmouth College, were also carefully considered.

The GCMP is not an isolated educational experiment, but rather an organized effort not only to adapt the best of these national curriculum recommendations to local school needs but also to build a sound program in areas where no such program exists. It is designed to effect curricular change in a controlled way rather than in the unplanned, hazardous way in which other changes often have been effected in the past.

To accomplish its purpose effectively, the GCMP makes extensive use of both the logical structure of mathematics and the discovery approach to learning. Students participate in challenging and exciting phases of mathematics and are led to discover, through the aid of skillful teaching, the fundamental concepts that are part of the logical structure of mathematics. Problem situations and experiences are presented in such a manner that discovery has a good chance of taking place spontaneously. Then, students are led to the established symbolism. The logical structure of mathematics stimulates the imagination of children and leads to an appreciation of mathematics as a dynamic and meaningful study. Continuity and creativity are stressed throughout the program.

The GCMP has been guided by the belief that computational skills should be introduced only after the concepts necessary for understanding the particular operations have been developed and the children have demonstrated a grasp of them. The mathematics of the program is presented in a carefully integrated, sequential form in which there is a continuous flow of ideas. Old ideas are examined in the light of newly formed concepts, and the search for patterns and relationships is carefully stressed.

At each stage of the program the child works with challenging problems and is encouraged to consider all of the ways in which these problems might be attacked. He then tries original or unusual approaches in looking for a solution.

Mathematicians agree that the real power of mathematics is in isolating logical patterns which exist in many seemingly dissimilar situations, systematizing these patterns, and applying them to the solution of new problems. The discovery approach allows the child to participate in this process and to feel the thrill that comes from being a party to the creation of a mathematical principle or idea.

Teachers have found that, with proper guidance, most children can uncover the essential relationships and structural properties originally discovered by the mathematical geniuses of the past, and are fascinated and excited by the accomplishment. It should be remembered that the idea or principle being developed is *new* to the child, even though it may have been originally expressed thousands of years ago.

In summary, then, GCMP is a systematic effort to develop an articulated kindergarten-through-grade-12 mathematics curriculum, and is designed to take advantage of the experiences of all earlier movements.

The basic guidelines of the GCMP are:

1. The basic program must be suitable for use by *all* students.
2. The program must have a continuous and systematic flow of mathematical concept formation from grades K through 12.
3. The program must originate at the lowest level of instruction in kindergarten or first grade and be continued through to grade 12.
4. The teaching approach should make the greatest possible use of the discovery method of teaching and provide continuous challenge and stimulation to the student.
5. The program must be mathematically correct and pedagogically sound.

Methods

The *Commentary for Teachers* outlines teaching procedures which move the student from concrete physical situations to their associated mathematical concepts. Principles are to be discovered by students through the use of the exercise material and other activities outlined in the commentary. Teachers are urged not to formulate principles or algorithms too early, but to allow students to formulate them. Principles and algorithms are developed with the material and eventually formulated and stated by the students and the teacher. After a concept has been developed and used, it is named. Students are then given story-problem situations in which they can apply new concepts and techniques that they have learned. The mastery levels are not specified.

Audio-visual aids to be used in each unit are listed together with suggestions for their use.

EXERCISE 5 - WORKSHEET

Assessing a Curriculum Description for Enquiry

Directions: After studying the description of the curriculum involved, fill in your ratings below and write down your reasons for making them. Check your answers against the Answer Key for the curriculum you chose.

CURRICULUM AREA: GRADE LEVEL:

NAME OF CURRICULUM:

1. Emphasis on teaching ideas rather than facts? H___ M___ L___ None___ ?___
   Basis for your rating:

2. Emphasis on teaching methods of enquiry used by scientists or scholars in the subject area? H___ M___ L___ None___ ?___
   Basis for your rating:

3. Emphasis on students making hypotheses? H___ M___ L___ None___ ?___
   Basis for your rating:

4. Emphasis on students testing hypotheses by examining evidence or investigating? H___ M___ L___ None___ ?___
   Basis for your rating:

5. Emphasis on student discovery of principles or rules? H___ M___ L___ None___ ?___
   Basis for your rating:

6. Emphasis on students conducting individual or group enquiry (problem-solving) projects? H___ M___ L___ None___ ?___
   Basis for your rating:

EXERCISE 5 - ANSWER KEY

Assessing a Curriculum Description for Enquiry

Explanation: The answers given below are not meant to be the only correct ones, since they reflect the judgments of the author of this unit. They should be helpful to you in checking your answers.

CURRICULUM AREA: Science GRADE LEVEL: K-6

NAME OF CURRICULUM: Science - A Process Approach

1. Emphasis on teaching ideas rather than facts? H✓ M___ L___ None___ ?___
   Basis for your rating:

   Facts are studied only in relation to developing or testing ideas.

2. Emphasis on teaching methods of enquiry used by scientists or scholars in the subject area? H✓ M___ L___ None___ ?___
   Basis for your rating:

   The central purpose of the program is teaching scientific modes of enquiry.

3. Emphasis on students making hypotheses? H✓ M___ L___ None___ ?___
   Basis for your rating:

   Formulating hypotheses is a major goal of the program.

4. Emphasis on students testing hypotheses by examining evidence or investigating? H✓ M___ L___ None___ ?___
   Basis for your rating:

   Students interpret data in testing their hypotheses.

5. Emphasis on student discovery of principles or rules? H✓ M___ L___ None___ ?___
   Basis for your rating:

   Inferring principles from data is an important emphasis.

6. Emphasis on students conducting individual or group enquiry (problem-solving) projects? H___ M✓ L___ None___ ?___
   Basis for your rating:

   The program aims to teach each student to be an active investigator.

EXERCISE 5 - ANSWER KEY

Assessing a Curriculum Description for Enquiry

Explanation: The answers given below are not meant to be the only correct ones, since they reflect the judgments of the author of this unit. They should be helpful to you in checking your answers.

CURRICULUM AREA: Biology GRADE LEVEL: Grades 10-12

NAME OF CURRICULUM: Biological Sciences Curriculum Study

1. Emphasis on teaching ideas rather than facts? H✓ M___ L___ None___ ?___
   Basis for your rating:

   There is a deemphasis on teaching facts.

2. Emphasis on teaching methods of enquiry used by scientists or scholars in the subject area? H✓ M___ L___ None___ ?___
   Basis for your rating:

   The entire program stresses learning scientists' modes of enquiry.

3. Emphasis on students making hypotheses? H✓ M___ L___ None___ ?___
   Basis for your rating:

   The program teaches students to make hypotheses.

4. Emphasis on students testing hypotheses by examining evidence or investigating? H✓ M___ L___ None___ ?___
   Basis for your rating:

   Investigations are conducted to test students' hypotheses.

5. Emphasis on student discovery of principles or rules? H✓ M___ L___ None___ ?___
   Basis for your rating:

   Students are encouraged to formulate their own principles.

6. Emphasis on students conducting individual or group enquiry (problem-solving) projects? H✓ M___ L___ None___ ?___
   Basis for your rating:

   Students conduct experiments.

EXERCISE 5 - ANSWER KEY

Assessing a Curriculum Description for Enquiry

Explanation: The answers given below are not meant to be the only correct ones, since they reflect the judgments of the author of this unit. They should be helpful to you in checking your answers.

CURRICULUM AREA: Math GRADE LEVEL: K-12

NAME OF CURRICULUM: Greater Cleveland Mathematics Program

1. Emphasis on teaching ideas rather than facts? H ✓ M___ L___ None___ ?___
   Basis for your rating:

   The program is concept-oriented, stressing thinking.

2. Emphasis on teaching methods of enquiry used by scientists or scholars in the subject area? H___ M___ L___ None___ ? ✓
   Basis for your rating:

   Not definitely stated in the description.

3. Emphasis on students making hypotheses? H ✓ M___ L___ None___ ?___
   Basis for your rating:

   Students make hypotheses.

4. Emphasis on students testing hypotheses by examining evidence or investigating? H ✓ M___ L___ None___ ?___
   Basis for your rating:

   Students test their hypotheses.

5. Emphasis on student discovery of principles or rules? H ✓ M___ L___ None___ ?___
   Basis for your rating:

   Students are led to discover math principles (rules).

6. Emphasis on students conducting individual or group enquiry (problem-solving) projects? H ✓ M___ L___ None___ ?___
   Basis for your rating:

   The discovery method is used in conducting problem-solving tasks. Story problems are used in the early grades.

References to Other Descriptions of Enquiry Curricula

In case you wish to turn to them, here are some key references to descriptions of various enquiry-focused curricula.

A Sourcebook of Elementary Curricula, Programs, and Projects

This 493-page compendium describes over 150 curricula, along with descriptions of instructional models, teacher training, and instructional resources. The curriculum descriptions follow a standard outline. The Sourcebook was compiled by the Far West Laboratory for Educational Research and Development in San Francisco. It is a product of that laboratory's ALERT Information System. The volume is for sale by the Superintendent of Documents, U.S. Government Printing Office. Stock Number 1780-1072.

Elementary Science Information Unit

This is a kit offering systematic descriptions of six elementary science curricula. There is a booklet for each curriculum and for each, a film strip and audiotape correlated with the filmstrip. The unit was developed by the Far West Laboratory for Educational Research and Development. It is distributed by the EPIE Institute, 463 West Street, New York, New York, 10014.

Social Studies Curriculum Materials Data Book 1971

This book presents two-page summary descriptions of a large number of social studies curriculum projects. The descriptions were done by the Social Studies Educational Consortium in Boulder, Colorado. The Consortium is the clearinghouse for social studies. It also publishes Curriculum Materials Analyses (CMAs) in booklets of about 20 pages. As of March 1971, 34 such booklets were available. The reports of the Consortium are available through the ERIC information system.

Clearinghouse on Science, Mathematics, and Environmental Education

This ERIC clearinghouse is located at Ohio State University in Columbus, Ohio. Its reports are available through the ERIC system.

Course and Curriculum Improvement Projects

The National Science Foundation, in 1970, published a description of the curriculum projects it was funding in the areas of mathematics, science, and social science. The report, Course and Curriculum Improvement Projects NSF 70-18, is sold by the Superintendent of Documents, U.S. Government Printing Office.

New In-Depth Evaluations of Social Studies Curricular Projects, Programs, and Materials

This special issue of Social Education describes 26 projects or programs in elementary or secondary social studies. The journal is published by the National Council for the Social Studies. The issue is Vol 36, No. 7 (November 1972).

Objective 6. Analyze and assess instruction in terms of the extent to which enquiry is taught.

An important way for you to apply your knowledge of enquiry is in examining instruction to determine the extent to which it teaches enquiry. This can accomplish two things. For one, it can strengthen your understanding of enquiry by teaching you to search out features of instruction that contribute to students' competence in performing enquiries. For another, it can give you experience in conducting analyses of instruction that would be helpful to school personnel in setting about to improve instruction in terms of enquiry.

Since it may not be feasible, observing instruction is optional. The material that follows deals with how you would plan for analyzing instruction in terms of enquiry. After studying this material, you will have the option of conducting an analysis of actual instruction in case you have the opportunity.

Planning an analysis of instruction in terms of enquiry

In planning observation of instruction to determine the extent to which enquiry is being taught, you need to do two things: specify the indicators (features) of enquiry instruction you would look for, and specify how you would conduct your data-gathering process. Exercise 6 that follows gives you the opportunity to think through this planning task before studying it further. In doing the exercise, select a curriculum area--science, social studies, or mathematics--at either elementary or secondary level. Then list the things you would look for in examining instruction in terms of enquiry. Finally, outline how you would go about getting the data you needed. There is no answer key for Exercise 6. Instead, the Worksheet is followed by a discussion of the planning process. Use this discussion in checking and rounding out the answers you gave on the Worksheet.

EXERCISE 6 - WORKSHEET

Planning the Analysis of Instruction in Terms of Enquiry

Directions: Choose a curriculum area for analysis, list things you would look for as indicators of enquiry instruction, and outline how you would conduct your observations in one or more classrooms.

Curriculum Area: Elementary___ Secondary___

Indicators of enquiry you would look for:

How you would conduct your data gathering:

In analyzing instruction to determine the extent to which enquiry is taught, you should look for the same features in the conduct of instruction that you looked for in descriptions of curricula. The difference is that now it is the conduct of instruction that is being examined. The features you should look for include the following:

An emphasis on teaching students the models of enquiry used by scientists or scholars in the subject when they obtain new knowledge in the subject area.

An emphasis on teaching students to hypothesize about cause/effect relationships within the subject area.

An emphasis on teaching students methods of testing hypotheses.

An emphasis on teaching students to offer explanations of phenomena.

An emphasis on having students conduct individual or group projects.

It will be particularly important to learn whether all students are taught competencies in enquiry, or whether this teaching is mainly limited to so-called gifted students. If the school uses ability grouping, for example, you should check whether enquiry is taught in the high groups but not in the groups made up of less-advanced students.

Also, it is important to check the extent to which instruction is focused on individual students rather than on the whole class. Do different students work on different tasks at a given time? Can students proceed at different rates? Do students have the privilege of choosing their own project tasks, or are all tasks assigned?

The second part of Exercise 6 asked you to indicate how you would go about getting data needed to analyze and assess enquiry instruction. A good starting point would be to examine the curriculum being used to determine what enquiry provisions were built into the learning materials being used. Also, it would be helpful to interview the teacher(s) whose instruction you wished to observe. This would give you an overview of the extent to which the teacher(s)

conceived enquiry as a learning goal and planned instruction to foster enquiry.

In observing instruction occurring in one or more classrooms, it would be a good idea for you to have a check list of enquiry features including those listed above. You might need to observe each class you selected two or more times to get an adequate sample of instruction for judging the amount of enquiry being taught.

An important way of checking and interpreting your observations would be to interview students about their notions as to what was important to learn in the subject. Also, you might re-interview the teacher(s) to check whether the conclusions you drew from your observations were accurate.

Conducting an analysis of instruction in terms of enquiry (optional)

If you have the opportunity (time and access to instruction) it will be valuable for you to apply your understanding of enquiry to the examination of actual instruction in the curriculum area of your choice. If you work in a school system, this should cause no difficulties. If not, you still may be able to conduct this analysis through using your contacts with a school system. Only about one-half day is required, unless you wish to conduct a survey of enquiry instruction in more than one classroom.

To assist you in conducting your analysis of enquiry instruction, the Worksheet for Exercise 7 is provided you to indicate categories of data you will need and to give you a convenient form for recording your data. You can, of course, work out your own categories and data forms. The Exercise 7 - Worksheet assumes you will observe just one teacher and one classroom. If you decide to make further observations, you may wish to duplicate the forms offered here.

Since this is an optional exercise and uses your data, no Answer Key is provided for Exercise 7.

EXERCISE 7 - WORKSHEET

Directions: In doing this optional exercise, either follow the procedure indicated in this Worksheet, or set up your own procedure and worksheet.

CURRICULUM AREA: GRADE LEVEL:

TEACHER: DATE OBSERVED:

TEACHER INTERVIEW NOTES

Teacher's report on degree of emphasis on teaching enquiry (problem solving)

Teacher's report on materials and equipment used in teaching enquiry

Teacher's report on instructional methods used to teach enquiry

--Teaching methods of enquiry scientists or scholars use in the field?

--Teaching students to make and test hypotheses?

--Teaching students to interpret phenomena using concepts and principles?

--Having students conduct individual or group projects?

Teacher's description of the class and class members' competencies in enquiry

EXERCISE 7 - WORKSHEET (CON'T.)

RECORD OF CLASSROOM OBSERVATION

Topic of lesson observed:

General conduct of lesson (lecture, class discussion, reading, projects, etc.):

Analysis of instruction in terms of categories of enquiry:

Teaching about models of enquiry used by scientists or scholars

Teaching students to hypothesize

Teaching students to gather data to test hypotheses

Teaching students to interpret phenomena in terms of concepts and principles

Having students conduct individual or group enquiry projects

Record of interviews with two or more students on what they learned in the lesson

Objective 7. Outline a plan for assisting a school district in introducing enquiry-focused instruction

This objective deals with putting together a knowledge of enquiry-focused instruction and a knowledge of the process a school district should go through in selecting any sort of change program. To do this, you need to use what this unit offers about enquiry and the skills covered in either of two other units of this training program: Unit 3 - Task Flow for Designing and Conducting Local Educational Improvement Programs, or Unit 8 - Selecting a Local Educational Improvement Plan. In performing this objective, it would be desirable for you to study either Unit 3 or 8 first. If you have not already studied one of these units, or if you do not now have the time to study one of them, you still can proceed with this objective without that background. Enough direction is provided here to enable you to perform the objective without having studied one of the other units.

Assume that a school district wishes to improve its emphasis on enquiry-focused instruction in a curriculum area. Assume you are called upon to offer assistance in performing two essential tasks: conducting a needs analysis to determine what shortcomings in the local program are to be overcome, and planning a change program that will make the needed improvements in the teaching of enquiry. What is the planning process you would follow in assisting the school district? The material below outlines this process and offers you practice in thinking through this process by performing two exercises. Since it is assumed that you will not engage in actual planning with a school district, the material offered covers only the steps to be taken in the planning process. The material is presented in two parts - conducting a needs analysis and selecting an improvement program.

Conducting a Needs Analysis

An instructional needs analysis has the purpose of determining what should be improved in an area of instruction and thus provides an essential basis for selecting the improvements to be introduced. A needs analysis breaks into three tasks that should be performed in sequence. These tasks are:

1. Specify instructional aims in the area of concern

   In the case of enquiry-focused instruction, this task calls for specifying the enquiry aims of instruction in the curriculum area.

2. Assess local shortcomings in accomplishing the specified aims

   Once enquiry aims have been specified, the task is that of determining how well, or how poorly, each is being achieved. This requires selecting appropriate assessment instruments and procedures, then gathering an appropriate sample of data on student achievement of each aim.

3. Identify likely causes of shortcomings

   In determining what changes are needed to remove shortcomings in accomplishing enquiry aims, it is very helpful to pinpoint faults in the instructional program that could account for those shortcomings. Is the curriculum being used inappropriate to those aims? Are teachers inadequately trained for teaching enquiry? Etc.

These three tasks are presented in detail in Units 3 and 8. You may wish to refer to one of those units before doing Exercise 8. This exercise calls upon you to think through the three steps of needs analysis. The Exercise 8 - Answer Key is meant to help you round out your understanding of the process of conducting a needs analysis. It is not meant to offer official correct answers.

EXERCISE 8 - WORKSHEET

Analyzing Needs for Improving Instruction in Enquiry

Directions: This exercise gives you the opportunity to think through the three key steps in conducting a needs analysis. Brief answers will be sufficient. After completing the worksheet, turn to the Answer Key for suggestions on points you may have missed.

---

1. Specifying enquiry aims: How would you recommend finding out what a school district desired to accomplish by way of teaching enquiry in a subject area?

2. Assessing shortcomings in accomplishing aims: Assume one aim in teaching elementary social science was that students learn how to plan a public opinion poll. How would you recommend determining how well students were learning this enquiry skill?

3. Identifying likely causes of shortcomings: Assuming students were not learning how to plan public opinion polls, what are some likely causes for this failure of the instructional program?

EXERCISE 8 - ANSWER KEY

Analyzing Needs for Improving Instruction in Enquiry

Explanation: The answers offered below are meant only to help you strengthen your understanding of conducting a needs analysis. They are not given you as the only correct answers.

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1. Specifying enquiry aims in a given curricular area

These are methods you might have recommended:

Examine the curriculum being used to determine its enquiry aims.
Consult with school leaders and teachers of the curriculum area.
Conduct a parent/teacher workshop to determine what enquiry aims parents would like instruction to cover.
In your leadership role, present a list of enquiry aims drawn from new curricula in the area and ask school staff members to indicate which of these aims they would like to include in the instructional program.

2. Assessing shortcomings in accomplishing an enquiry aim

In assessing students' capabilities in planning a public opinion poll, what is needed is a test in which students are asked to do the following sorts of things: listing the questions that are to be asked; deciding whether to use phone interviews, door-to-door interviews, or questionnaires; deciding what sort of sample of informants are to be polled; and indicating how the data are to be recorded and analyzed. The assessment need not test every student in the grades chosen for teaching this skill. A random sample of students will be sufficient. In addition to testing students, it probably would be valuable to interview a small number to learn how they think about the task of planning an opinion poll.

3. Identifying likely causes of shortcomings

There are two most likely causes for students' inability to plan an opinion poll. One is a lack of instructional materials for teaching this skill. The other is teachers' lack of understanding of polling procedures. You may have thought of other likely causes.

Selecting a Change Program to Improve Instruction in Enquiry

The process of selecting (or designing) a change program depends on taking three sets of information into account: results of the needs analysis that indicate what sorts of improvements are needed, resources available nationally that could provide the needed improvements, and local factors favoring or opposing the adoption of any resources judged to be appropriate for meeting the needs for improvement. These three aspects of selecting a change program are introduced in Unit 3 of this training program (Task Flow for Designing and Conducting Local Educational Improvement Programs) and are treated in detail in Unit 8 (Selecting a Local Educational Improvement Program).

In conducting a resources search you naturally would start with a list of those enquiry aims the school district was not successful in accomplishing, and with the list of most likely causes for these shortcomings. Many resources are available nationally. Your problem would be to survey these resources related to needs for improving the local program. Where would you turn? A good start would be to locate experts in enquiry-focused science instruction (perhaps in the state education department or a local university) and get their best advice as to resources likely to meet local needs or as to sources where the required information could be found. Turning to the Education Index for references to the literature would be an important step. Another source to turn to is the Educational Resources Information Center (ERIC) that gives access to a great deal of information about educational innovations of all kinds. Another good source would be any nearby school district that stressed teaching enquiry in the curriculum area with which you were concerned. Obviously you would want to examine various enquiry-focused curricula in the area.

Once two or more resources were located that promised to meet the local

needs for improvement, the task would be to assess local factors that would be important in deciding which of the resources to adopt. These factors obviously include costs of adopting each of the resources tentatively selected. Thus adopting a new curriculum might be highly desirable but prohibitively expensive. Attitudes of the local staff toward adopting any of the resources also would be highly important. The preference of the Associate Superintendent for Instruction might be decisive. Teachers' views would need to be taken into account. Another important basis of decision would be the amount of difficulty of implementing a resource. Thus a new curriculum might call for major changes in instructional procedures that the school district was not prepared to undertake. On the basis of this analysis of local factors, one or more of the resources being considered would be chosen in preference to others. Of course, in your leadership role, you might influence local staff members to change their attitudes about adopting alternative resources by pointing out special advantages or disadvantages of the different resources.

Exercise 9 offers you the opportunity to think through this process of selecting a set of changes to improve enquiry instruction. You are given the results of a needs analysis and asked to suggest how to proceed in locating and selecting resources to meet those needs. After you complete the Exercise 9 - Worksheet, turn to the Answer Key to compare your recommendations with those offered there.

Exercise 9 completes this unit. When you have completed the exercise and checked your answers with the Answer Key, proceed to the Post-Assessment Exercise that follows.

EXERCISE 9 - WORKSHEET

Selecting a Change Program to Improve Instruction in Enquiry

Directions: In performing this exercise, select a curriculum area and a level of instruction (elementary or secondary) for your example. Assume that the school district has conducted a needs analysis indicating the need for a different curriculum in the area and for an in-service program of teacher education for enquiry. Fill out the three parts of the exercise with your recommendations. The Answer Key does not provide the only correct answers but can help you check and round out your understanding of of the process of selecting a change program.

CURRICULUM AREA: _____ LEVEL: Elem___ Sec___

1. Surveying resources to meet the identified needs for improvement

2. Analyzing local factors favoring or opposing adoption of resources

3. Making the choice of resources to be adopted

EXERCISE 9 - ANSWER KEY

Selecting a Change Program to Improve Instruction in Enquiry

Explanation: The points presented in this Answer Key essentially review those made just before this exercise on pages 75-76. They are stated here to help you check the answers you gave on the Worksheet.

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1. Surveying resources to meet the identified needs for improvement

The following is a listing of key steps to take in locating resources, either in the form of enquiry curricula or in-service teacher education for enquiry:

Seek the advice of experts in enquiry-focused instruction in the subject, located in the state education department, local universities, or elsewhere.

Search the education literature for appropriate resources.

Examine curricula and in-service teacher education programs stressing enquiry.

Visit school systems stressing enquiry-focused instruction in the subject area.

2. Analyzing local factors favoring or opposing the adoption of resources

These are the sorts of information on local factors you should obtain:

Local financial resources to make the needed changes in curriculum and staff training.

Attitudes of school leaders and teachers about adopting each of the resources being considered.

Availability of leadership in the district for implementing resources.

Difficulty level of implementing each of the resources being considered.

3. Making the choice of resources to be adopted

Here the task is to match up information about the probable improvements each resource being considered would make and local factors favoring or opposing the adoption of each resource.

The choice of a curriculum and of an in-service program should be made to achieve the best combination of a promising resource with favorable local factors concerning its adoption.

POST-ASSESSMENT EXERCISE - UNIT 5

Directions: This exercise is the same as the Pre-Assessment Exercise which you completed at the beginning of your study of this unit. Review your estimates of mastery of the items in the Pre-Assessment Exercise (page 10); you need do only those items on the Post-Assessment Exercise which you judged to be less than on target. Then check your answers with the Pre- and Post-Assessment Exercise - Answer Key.

---

1. Define enquiry and indicate its essential components.

2a. Why should schools emphasize teaching all students how to enquire?

2b. Should schools seek to have students acquire knowledge and skills in a curriculum area mainly through conducting enquiries? Explain your answer.

3. How are ideas (concepts and principles) related to enquiry?

4. List key steps or stages in the enquiry process.

5. What features would you look for in a curriculum to determine the extent to which it teaches enquiry?

6. What features would you look for in the conduct of instruction to determine the extent to which it teaches enquiry?

7. What should you be prepared to do if called upon to help a school district set about to improve instruction in enquiry within any curriculum area?

Note: To check your answers, turn to the Pre/Post Assessment Exercise - Answer Key at the end of the unit.

PRE/POST ASSESSMENT EXERCISE - ANSWER KEY

1. Define enquiry and indicate its essential components

Enquiry is the process of thinking and action involved in problem solving. Problem solving occurs when a solution must be worked out rather than arrived at by using a recipe or appealing to an authority or expert.

Requirements for enquiry are that the enquirer confronts a problem (need, difficulty, purpose), selects or devises an approach to its solution, and proceeds largely on his own toward a solution.

2a. Why should schools emphasize teaching all students how to enquire?

Competencies in enquiry give the individual the capability of interpreting and controlling his experience. Also, enquiry is important in living because rapid change in modern society requires the ability to adapt to ever new and unpredictable events.

2b. Should schools seek to have students learn knowledge and skills in a curriculum area mainly by conducting enquiries?

The key point here is that learning through conducting enquiries is a very time-consuming matter. Also, many of the things learned by scientists or scholars are very complicated, requiring immense skill or knowledge. No student could learn more than a tiny fraction of the knowledge in an area through his own enquiries. However, the student should learn how to conduct enquiries so that, when appropriate, he could conduct them on his own.

3. How are ideas (concepts and principles) related to enquiry?

Most enquiries are not concerned mainly with gathering facts. Instead, they involve relations of cause and effect, either to discover or apply knowledge of relationships in explaining phenomena, or in achieving desired outcomes. Ideas in the form of concepts and principles are essential in the study of relationships or in arriving at solutions to problems.

4. List key steps or stages in the enquiry process

The enquiry or problem-solving model presented in this unit contains eight steps or stages. Your model may differ from this as long as it contains similar elements. The eight steps are:

Identify a problem
Analyze the problem
Search for a solution
Choose a solution (for a trial)
Prepare to try the solution
Try the solution
Evaluate the solution (Was it successful?)
Decide on a post-tryout course of action (Accept the solution? Try another? Etc.)

PRE/POST ASSESSMENT EXERCISE - ANSWER KEY (CON'T.)

5. What features would you look for in a curriculum to determine the extent to which it teaches enquiry?

These are key features of a curriculum focused on teaching enquiry:

Emphasis on teaching ideas rather than facts
Emphasis on teaching the methods of enquiry used by scholars or scientists in the area covered by the curriculum
Emphasis on teaching students to discover principles or rules
Emphasis on teaching students to hypothesize and test hypotheses
Emphasis on having students conduct individual or group projects

6. What features would you look for in the conduct of instruction to determine the extent to which it teaches enquiry?

These are important indicators of enquiry to look for in analyzing instruction:

Do students learn models for conducting enquiries in the curriculum area?
Are students taught to hypothesize and to test hypotheses with data?
Are students taught methods of gathering data?
Are students engaged in offering explanations of phenomena?
Is there an emphasis on having students conduct individual or group projects rather than on whole-class lectures or discussions?

7. What should you be prepared to do if called upon to help a school district set about to improve instruction in enquiry within any curriculum area?

The leadership you should be prepared to offer includes the following:

Helping the school district specify its goals for enquiry teaching
Helping the district plan and conduct an assessment of present successes and shortcomings in teaching enquiry
Helping the district analyze causes for shortcomings in enquiry teaching: inadequate learning materials and equipment? faulty teacher skills? Etc.
Helping identify resources that could strengthen enquiry teaching
Helping the district choose the resources to be employed to strengthen the program
Helping the district implement and evaluate the improvements chosen

UNIT EVALUATION FORM

Unit 5.. Enquiry as a Theme of Educational Reform, with Related Innovations

Evaluation by_____ Date_____

Position_____ Organization_____

Please give your reactions to this unit by checking and writing in your opinions and recommendations. Returning this form to Research for Better Schools, 1700 Market St., Philadelphia, Pa. 19103 (Attention: Glen Heathers) will help us judge the value of the unit as well as aiding in its revision.

A. Your judgment on the importance of a unit on this topic as training for leadership in local educational improvement programs.

Check: Very High____ High____ Moderate____ Low____ Very Low____

Your comments:

B. Your judgment of the quality of the introductory section of the unit.

Check: Very High____ High____ Moderate____ Low____ Very Low____

Your comments:

C. Your judgment of the adequacy of the set of unit objectives.

Check: Very High____ High____ Moderate____ Low____ Very Low____

What objectives do you recommend omitting? Why?

What objectives do you recommend adding? Why?

D. Your judgment on the quality of the unit contents.
Check: Very High____ High____ Moderate____ Low____ Very Low____
Your comments:

E. Your judgment on the quality of the unit exercises.
Check: Very High____ High____ Moderate____ Low____ Very Low____
Your comments:

F. Your judgment on the quality of the unit pre- and post-assessments.
Check: Very High____ High____ Moderate____ Low____ Very Low____
Your comments:

G. About how many hours did you take to complete this unit?_____

H. How valuable do you judge this unit to be for training each of the following categories of educational leaders? Please enter the appropriate symbol.
H - Highly valuable. M - Moderately valuable. L - Low value

____ School system central administrators

____ Building principals

____ Curriculum coordinators

____ Field consultants of state education departments

____ Graduate students in administration or supervision

____ Other: